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The effects of adding salts to the soil on the amount of non-available water*

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In the experiments described in the following pages an attempt has been made to determine the effect upon the amount of non-available water, when varied amounts of sodium chloride or the salts of a full nutrient solution have been added to the soil. It has been found that with a soil of pure silica, containing about 0.03 per cent. of calcium, aluminum, and iron,† the amount of non-available water is not altered by the addition of either sodium chloride or the salts of a full nutrient solution. In the case of the sodium chloride series, at least, the water was used up by the plants faster than the salts, and as the point of non-available water was approached, the concentration of the soil water must have increased. In many cases the amount of sodium chloride was so great that the saturation point of the salt was passed long before the plant wilted. Adsorption, in some form or other, took place. We are concerned here then, not only with non-available water but also with the adsorption of salts from soil solutions.

PREVIOUS WORK ON NON-AVAILABLE WATER

In the late summer of 1859, Sachs[16] determined the retarding influence on transpiration, of various salts and soils. He then determined the amount of water retained by soils when tobacco

*Contributions from the Department of Botany of the University of Missouri no. 18.

†See table of mechanical analysis of soil on page 279.

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plants wilted in a moist atmosphere. The soils used were a mixture of black beach humus and sand, a loam, and a pure sand (ground quartz). He found different amounts of non-available water in each of the soils; the beach humus having the greatest amount and the sand the least. He pointed out the importance of determining the amount of water available to plants in various soils, and showed that it bears no fixed relation to the amount of water which the dry soil will take up and hold (saturation capacity). He attributed the greater amount of non-available water in the humus soil to the greater adhesion between the water and the soil.

From the time of Sachs' paper, until Bogdanhoff[1] published his paper in 1893, but little attention was given to the subject of non-available water, though soil moisture received the attention of a great many investigators. In his paper, Bogdanhoff pointed out the errors introduced through chemical changes, when hygroscopic water is measured by determining the loss of weight in soils dried in an oven at 100° C. He found percentages of hygroscopic water, as measured by germinating seeds used as an indicator. Seeds were soaked until they had absorbed amounts of water nearly sufficient for germination. They were then mixed with the soil to be tested, using an excess of seeds, and stirring from time to time, so that all particles of the soil came in contact with the seeds. Seeds in this condition have strong absorptive powers and are able to take water from a relatively dry soil and begin growth. Varying percentages of water were mixed with a particular soil, and the lowest percentage which would permit growth determined.

In a sand containing 0.15 per cent. (by dry weight) of water, seeds germinated after 19 days; while in a sample containing 0.09 per cent., the seeds did not germinate, but lost water to the sand. He made measurements with samples of clay, but did not compare the clay with the sand, since the amount of germination could not be accurately determined, and the temperatures in the two sets of experiments were not held alike.

Heinrich,[9] in 1894, determined the amount of water contained in soils when plants begin to wilt, and also determined the hygroscopic water content. The hygroscopic water was determined by

spreading the soils on a watch glass, and exposing them for one week to an atmosphere saturated with water vapor. The increase in weight was used as a measure of the hygroscopic water. His results show that, while the plant can live in a relatively dry soil, it can not use the hygroscopic water.

Edmond Gain[6] repeated the experiments of Sachs "with many plants in order to settle the following questions: (1) Is the power of resistance to drought of a given plant the same in different soils? This question must be answered in the affirmative. (2) Is the water content of the soil, at the time the plants wilt, the same for all stages of plant growth? No, it fluctuates in such a way as to produce a curve." He did not report the methods employed, nor give an analysis of the soils used.

A number of determinations of the amount of non-available water in various soils were made by King.[11] He concluded that one of the reasons why the clayey soils retained more water than the sands is because the small grains of the clay present more surface for retaining the water, the thickness of the film being the same in all cases. He gave a formula for computing the percentage of moisture in a soil which a given thickness of film will produce. By the use of this formula, a set of theoretical values was obtained, for the soils studied, which agree very closely with the percentages of non-available water found.

In 1902, Hedgcock[8] considered the relation of heat, light, and humidity to the amount of non-available water. His methods were such that he could not vary one factor while the others remained constant. The results as a whole would seem to show that any condition which lowers the vigor of the plant, raises the amount of non-available water. When he compared the various soils, he found that the amounts of non-available water retained by the soils increased in the following order: sand, loess, clay, loam, humus, saline soil. Judging from the sizes of the soil grains, the clay should have come after the saline, with the highest percentage. Hedgcock concluded that some factor other than the extent of soil surface is involved. The percentage of dissolved substances in the soil solution was the only condition noted that varied in the right direction. He, therefore, concluded that as the soil water diminishes, its concentration increases until finally

it becomes so concentrated that plants are unable to absorb more. He went so far as to formulate a law, that the percentage of non-available water in soils increases as the square root of the percentage of soluble salts.

Before using, all soils were sifted with a screen possessing a quarter-inch mesh. Other than this, the physical condition of the soil was not given closer attention than to list it as "loose, medium, or hard in density." A plant was considered, by him, wilted, when its youngest leaves wilt strongly. This would seem to be a very unreliable criterion, for many plants, at least. A geranium, for instance, will not only maintain its younger leaves, but will put out new shoots, after its roots have been killed. Many other plants behave in a similar manner.

Besides the above, a number of determinations of the amount of non-available water have been compiled, but aside from their local and immediate interest, they add nothing to our knowledge of non-available water.[10, 12, 17, 19]

ADSORPTION BY SOILS

The work done previous to 1908, on adsorption, has been recently reviewed by Patten and Waggaman,[14] so that a review of the literature need not here be given. The salient facts of interest in this connection are: Certain solids and liquids draw unto themselves and retain within their structures, or on their surfaces, other solids, liquids, or gases.* This is called *absorption*.

A special case of absorption, termed *adsorption*, is defined as the existence of a difference in concentration or density of a film adjacent to a bounding solid and the concentration or density of the mass of the liquid or gas which bathes the solid.†

Whether the relation between the adsorbing and adsorbed substances is physical or chemical, is not always clear; sometimes it appears to be one, sometimes the other. The difficulties involved in quantitative determination leaves us without a unit of adsorbing power, and with very few formulæ expressing the rate or conditions of adsorption.

When an adsorbent is brought into contact with a solution containing two or more solutes, these solutes may be adsorbed in

* *Loc. cit.* 10.

† *Loc. cit.* 11.

different degrees, so that a more or less complete separation of the solutes is effected. Further separation may be reached by using two or more adsorbents, each with an adsorbing power specific for each solute. A number of investigators have used organic substances, such as charcoal, paper, and cotton to effect such separations. The separation is seldom complete, the adsorbed substance being distributed between the adsorbent and the solvent. No general laws governing the ratios of such distribution have been established.

The solvent itself is often adsorbed, so that it increases very much in density at the surface of the adsorbent. This changes many of its physical characteristics; for instance, it is often able to hold the solute in solution at a concentration many times greater than normal saturation. This change in concentration is often accompanied by temperature changes which indicate enormous forces at work. The pressure of the water surface about a small solid (soil grain) has been estimated to have a magnitude of from 6000 to 25,000 atmospheres, or approximately 150,000 pounds per square inch.*

Now the soil grains present acres of surface to the soil solution, which, existing as it does, for the most part, in surface films is continuously within the field of adsorptive forces. We must expect, therefore, that adsorption will play important roles in the soil. Not only is the chemical content of the soil-solution affected, mineral nutrients stored up,[15] and toxins held harmless,[5] but the physical relations of the soil grains themselves are influenced.†

The field has been but little investigated, and most of the work has been done from the standpoint of physics and chemistry. Only a few investigators have taken up the problem from the standpoint of the plant, using it as an indicator. It would seem that this must be the ultimate point of attack, for the root hairs come into such a relation with the soil grains as to find a solution, the nature of which can be but little understood by any amount of study of the leachings from treated soils.

*Whitney, Soils of the United States. U. S. Dept. Agric. Bur. Soils Bull. 55: 11. 1909.

†Cameron, F. K. and Gallagher, F. E. Moisture content and physical condition of soils. U. S. Dept. Agric. Bur. Soils Bull. 30: —. 1908.

Not only this, but the root hairs, with their cellulose walls, are absorbents, and undoubtedly engage in selective absorption with the soil grains, so that there are ratios of distribution, between the soil grain, the film of soil water, and the cell wall.[18] Physiological processes in the plant will continually disturb the equilibrium of distribution. A series of changes must then follow before the equilibrium is again established. It was with the hope of getting some data regarding the nature of this equilibrium that the experiments described below were undertaken.

EXPERIMENTS AND RESULTS ON THE INFLUENCE OF SALTS ON NON-AVAILABLE WATER

From a number of plants used in preliminary experiments, wheat was selected as most suitable. Its superiority lies in the smallness of its seed, so that it early becomes dependent upon the soil solution, and in the tenderness of its leaves, which makes it very sensitive to a deficient water supply. Some of the plants were grown in paraffined baskets; others in flower pots dipped in hot paraffin. Both the baskets and the pots seemed to give good results, but the pots were easier to prepare. Later, when it was found, by weighing the empty pots, that they had slowly absorbed water, their use was discontinued. Glass tumblers were then tried, and were found very satisfactory. The roots spread evenly through the soil, showing no tendency to mat about the inner surface of the glass.

In the first experiments, the plants were grown in river-washed sand, but in the experiments from which the data given below were taken, the plants were grown in clean crushed quartz, obtained from a supply house. The chemical analysis of the quartz, furnished by the supply house, is as follows:

	Per cent.
Absolute silica	99.97
Iron, aluminum, calcium	.03
	100.00

The fresh samples were very white, but, after standing, a yellow tint, just perceptible when old samples were compared with new, was noted. This was probably due to thin films of iron oxide which formed on the surface of the grains.[4] The physical analysis is given in the table below:

	Size.	Per cent.
Gravel	2 mm. +	0.00
Fine gravel	1–2 mm.	0.00
Coarse sand	1–.05 mm.	3.60
Medium sand	0.5–0.25 mm.	20.51
Fine sand	0.25–0.1 mm.	72.72
Very fine sand	0.1–0.05 mm.	2.69
Total		99.52

A full nutrient solution was made up as follows:

		Gm.
Calcium nitrate $Ca(NO_3)_2+4H_2O$	15.83 gm. = $Ca(NO_3)_2$	11
Potassium nitrate	KNO_3	3
Magnesium sulphate $MgSO_4+7H_2O$	6.85 gm = $MgSO_4$	3
Potassium phosphate	KH_2PO_4	3
Total		20

Water to make 10,000 c.c. of solution.

This solution gives a concentration of salts equal to 0.2 per cent. The same stock solution was used throughout the entire series of experiments. To portions of this full nutrient solution, quantities of sodium chloride were added so that series of concentrations (salts of full nutrient solution plus sodium chloride) of the following order were made: 0.2 per cent. (control), 0.225 per cent., 0.25 per cent., 0.3 per cent., 0.4 per cent., 0.5 per cent., 0.65 per cent., and 0.8 per cent. In another series, the percentage of the total salts in the nutrient solution was increased, so that, without the use of the sodium chloride, the following series of concentrations were made: 0.2 per cent. (control), 0.25 per cent., 0.4 per cent., 0.6 per cent., and 0.8 per cent.

The solutions were made upon the percentage basis, because it is impracticable, when dealing with selective adsorption and water films, to make up solutions in the ratios of their osmotic strengths. Moreover, the questions in mind can be answered equally as well with simple percentage solutions.

Sodium chloride seemed a suitable salt to use since it does not readily penetrate plant protoplasm and since it ordinarily contains no water of crystallization. Further, Briggs[3] has shown that sodium chloride is but slightly adsorbed by quartz. The series without the sodium chloride served as a check on the purely toxic effects of the sodium chloride.

The quartz was wetted with the solution, so that it contained a 20 per cent. (20 grams of solution, plus 100 grams dry quartz)

soil moisture. The air-dry quartz was weighed out, to the 1/10 gram, in portions sufficient nearly to fill the tumblers. It was then spread over the bottom of a tray. The solution was added to the quartz in such a manner as to prevent, as far as possible, any uneven adsorption of the salts by the soil grains first wetted. After quickly mixing, the soil was dropped into the tumblers. When this quartz is carrying a 20 per cent. soil solution, it contains more than its optimum amount of water.* However, it was dropped into the tumblers in such a manner as to include air enough to supply the plants as long as it was necessary to grow them. By pounding the tumblers up and down on the table a few times, the inclosed air was worked out of the upper centimeter of the soil, which puddled, leaving a thin layer of free water on the upper surface. This also worked the air entrapped below the surface into quite large bubbles, the largest being about 5 mm. in diameter. The physical condition of the soil, thus obtained, appeared to be uniform throughout both series.

Melted paraffin was poured over the surface of the quartz in each tumbler, five small holes were made through the cover thus formed, and then the wheat seeds, which had germinated in Zurich germinators until the radicles were from five to ten millimeters long, were dropped through the holes into the water layer on the surface of the soil. Five tumblers of each concentration were set up.

The plants were grown in the glass house on a table in the center of the room, where they were under similar conditions, until they were ready to be wilted down. There was a marked difference, among the several concentrations, in the rate and amount of growth. With the exception of the 0.225 per cent. set, in which there was a stimulation, due undoubtedly to toxic effects, there was a regular decrease in both the rate and the amount of growth from the control set to that of the highest concentration. Plants that grew fastest used up their water first and were the first to wilt.

When the water was nearly used up, as was determined by repeated weighings of the tumblers, the plants were put into a

*It was necessary to use an excess of water so as to have enough to allow the plants to put on sufficient growth before wilting.

culture case, where a relative humidity of approximately 10 per cent. was maintained. The culture case, as described in another paper,[2] contained a thermograph, a hygrograph, and an electric fan. The humidity was controlled by regulating the volume of a stream of air, dried by passing through sulphuric acid, and forced into the case by means of an air pump.

Wilting the plants in a relatively dry atmosphere, practically solved the problem of knowing when to consider them wilted. These plants did not show temporary partial recoveries from the drouth effects, as others did which were grown under fluctuating conditions of humidity. Moreover, the leaves dried out immediately after death, so that it was possible to see the progress of death over the various members of the plant and to have each culture stopped at the same stage of wilting—a very important detail in non-available water determinations. A study to determine the effects of relative humidity on non-available water is now in progress, but the results of this study are not necessary for the present paper, since in the experiments here reported, all of the plants were under like conditions of humidity.

As soon as the plants had wilted, the tumblers were removed from the case, and the amount of non-available water determined in the following manner: The quartz was passed through a screen, having 20 meshes to the inch, which removed all the roots. A sample of about 80 grams of the quartz was put into an aluminum dish and weighed on a chemical balance.* The sample was then dried at 110° C. for one week. It was found that this amount of desiccation was sufficient to insure constant weight.

From the loss of weight in drying, the percentage of non-available water was determined, then the total water remaining in the soil was calculated, also the concentration which this water would have had, had it existed as free water,—assuming that the plants had used up none of the salts and neglecting any water of crystallization. The results of the determinations are given in the following table:†

*These operations were carried on in the laboratory and probably permitted some experimental error to enter. However, as little time as possible was consumed before the weighings were made. The sifting was done in a small closed vessel.

†The numbers refer to the amount of salts added; thus 25a means that a 0.25 per cent. solution of sodium chloride and full nutrient salts were added to the quartz. Sets from *a* to *e* contain sodium chloride, sets from *l* to *p* contain no sodium chloride.

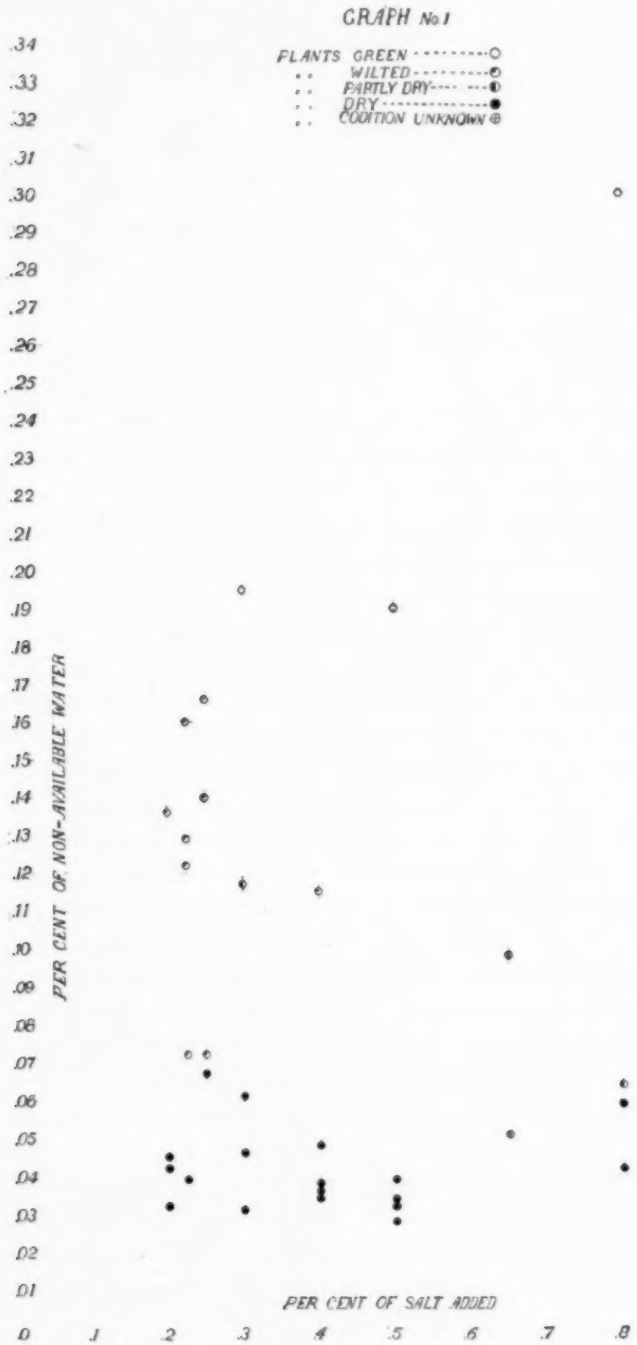
Number.	Amount of desiccation.	Per cent. of non-available water.†	Total concentration of all salts in per cent.	Concentration of sodium chloride in per cent.
2a	———	——	——	——
2b	dry	.03	125.	——
2c	wilted	.14	29.4	——
2d	dry	.05	87.	——
2e	dry	.04	94.	——
225a	wilted	.16	28.1	3.1
225b	wilted	.12	37.	4.1
225c	wilted	.07	62.5	7.
225d	dry	.04	115.7	12.9
225e	wilted	.13	34.8	3.9
25a	———	——	——	——
25b	wilted	.07	69.5	13.9
25c	wilted	.14	35.5	7.1
25d	dry	.07	74.8	15.
25e	wilted	.17	30.	6.
3a	dry	.03	192.5	64.2
3b	dry (partly)	.12	51.3	17.
3c	dry	.06	98.2	32.7
3d	wilted	.19	31.	10.3
3e	dry	.05	129.5	43.
4a	———	.04	206.	103.
4b	wilted	.11	69.1	35.
4c	———	.05	162.	81.
4d	———	.04	210.	105.
4e	dry	.04	231.	115.
5a	dry	.04	252.	151.
5b	dry	.03	315.	189.
5c	dry	.03	352.	212.
5d	green	.19	53.	32.
5e	dry	.03	312.	187.
65a	———	——	——	——
65b	———	.10	132.	91.5
65c	———	.05	254.	175.5
65d	———	——	——	——
65e	———	——	——	——
8a	green	.376	43.	31.
8b	dry	.06	275.	207.
8c	dry (partly)	.06	254.	190.
8d	green	.31	52.3	39.
8e	dry	.04	388.	292.
2l	dry	.18	27.2	——
2m	wilted	.25	16.	——
2n	dry	.06	55.	——
2o	wilted	——	——	——
2p	dry (partly)	.14	29.	——
25l	dry	.13	37.5	——
25m	dry (partly)	.18	27.5	——

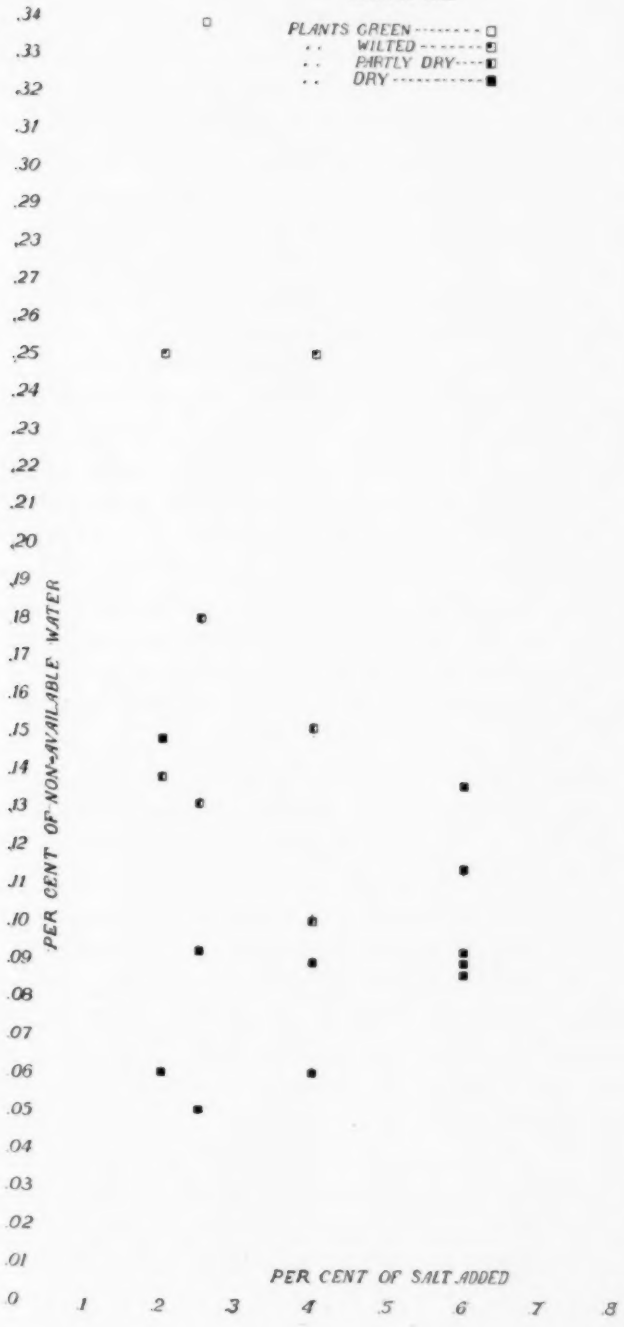
†Recorded to nearest 1/100 per cent. only.

Number.	Amount of desiccation.	Per cent. of non-available water.†	Total concentration of all salts in per cent.	Concentration of sodium chloride in per cent.
25n	green	.34	15.	
25o	dry	.09	54.	
25p	dry	.05	98.	
4l	dry	.06	125.	
4m	dry (partly)	.15	52.5	
4n	dry	.09	90.	
4o	wilted	.25	32.	
4p	dry (partly)	.1	79.5	
6l	dry	.14	89.	
6m	dry	.09	128.5	
6n	dry	.09	141.	
6o	dry	.11	105.	
6p	dry	.09	140.	

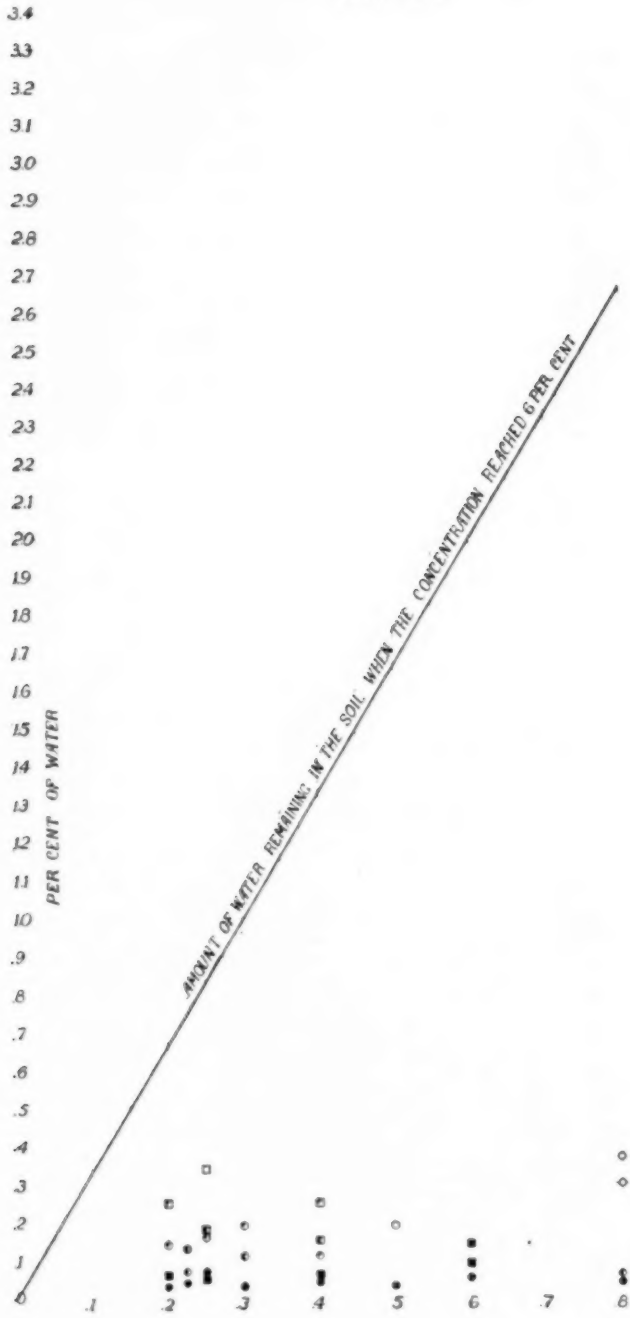
The non-available water relations are more clearly represented by the graphs 1, 2, and 3. Graphs 1 and 2 are details of the sodium chloride and the full nutrient series, respectively. Graph 3 is a combination of 1 and 2, enlarging the scale of the ordinate 10 times, and indicating the determinations only in part. Referring to graphs 1 and 2, it will be seen that, with but a single exception, the amount of non-available water in the soil varies with the amount of desiccation which the plant has experienced. Cultures in which the plants are just beginning to wilt have the most; and those in which plants have dried have the least. Also, even in the culture containing the highest percentage of non-available water, the soil solution represents a concentration of 43 per cent. That the plant actually lived in these high concentrations is shown by the fact that in some cases the plants were still green when the sample was taken. Further, cultures in which plants are completely wilted, *i. e.*, plants just beginning to dry, have about 0.1 per cent. of non-available water, regardless of the amount of salts in the culture. Drawn across graph number 3, is a line representing the amount of water which the several sets had when the concentration of the soil water had reached 6 per cent. It is to be noted here that the plants in the cultures were not exposed to free water containing 6 per cent. of salt. The 6 per cent. curve lies so low that all the water in the quartz was in the form of *film water*, before this concentration was reached. No data have been found regarding isotonic values in film-water, a

†Recorded to nearest 1/100 per cent. only.


GRAPH No 1
PLANTS GREEN
WILTED
PARTLY DRY
DRY
CONDITION UNKNOWN
PER CENT OF NON-AVAILABLE WATER
.34
.33
.32
.31
.30
.29
.28
.27
.26
.25
.24
.23
.22
.21
.20
.19
.18
.17
.16
.15
.14
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
0
.1
.2
.3
.4
.5
.6
.7
.8
PER CENT OF SALT ADDED


GRAPH No.2
PLANTS GREEN
WILTED
PARTLY DRY
DRY
PER CENT OF NON-AVAILABLE WATER
.34
.33
.32
.31
.30
.29
.28
.27
.26
.25
.24
.23
.22
.21
.20
.19
.18
.17
.16
.15
.14
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
0
PER CENT OF SALT ADDED
1
2
3
4
5
6
7
8

GRAPH No.3


PER CENT OF WATER
AMOUNT OF WATER REMAINING IN THE SOIL WHEN THE CONCENTRATION REACHED 6 PER CENT
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
.1
.2
.3
.4
.5
.6
.7
.8

form of water which land plants use for a large part of their lives. The uniformity in the above results testifies to the smallness of experimental errors in sampling, weighing, et cetera.

The amount of non-available water was not determined in the 0.8 per cent. set of the full nutrient series, as these plants were used for a study of some of the physiological conditions of the plants at wilting time. One point, of vital interest here, is the amount of adjustment to concentrated solutions which the plants may have made.

The cell sap of the roots of normal wheat plants is isotonic with solutions which contain a concentration of sodium chloride lying between 3 per cent. and 6 per cent. A plant was removed from the tumbler of the 0.8 per cent. set, after all the plants in the tumbler, save this one, had wilted. The plant was removed by sluicing with a small stream of water, a number of uninjured root tips thus being obtained. The root tips were placed on a slide, under the microscope, and the concentration of the cell sap in cells of the tip was determined by the plasmolytic method. There was no plasmolysis with a 3 per cent. sodium chloride solution. A 6 per cent. plasmolyzed. Turgor was restored by tap water, the cells appearing normal in every way. The plants, therefore, did not adjust themselves to the various soil solutions by materially increasing the concentration of their cell sap.

There were, however, visible modifications in the plants due to the influence of the salts added. Increase in the amount of bloom, as mentioned by Harter,[7] was not observed, but there was a uniform decrease in the rate of transpiration. The leaves of the plants grown in the higher concentrations felt harsh to the fingers. A microscopical study of the leaves was not made, but possibly this harshness was due to some modification in the structure of the cell walls, as found by Harter. As mentioned above, there was a correlation between the size of the plants and the amount of salts added, the plants in the higher concentrations being much smaller. This is of special interest, for not only was the area of leaf surface reduced, in plants grown in the higher concentrations, but their root systems were proportionately reduced. In the 0.8 per cent. set the roots developed only in the upper one third of the tumblers. It follows, therefore, that the

roots of the plants in the higher concentrations came into contact with a much smaller proportion of the total surface presented by the soil grains. Yet, the percentage of non-available water, remaining in these tumblers, was no greater than that found in the lower sets, which indicates a water transfer from the more remote parts of the tumbler to the root systems of the plants. At first, when the soil was very moist, this transfer might have been made by the movement of the liquid water over the soil surfaces, but as these films became thinner, the movement would become slower, and at last, when the films became discontinuous, the movement would stop altogether. The only method of transfer, then, would have been in the form of vapor, and before the soil moisture could have been reduced to as low a percentage as was found in these experiments, this kind of transfer evidently must have taken place.

But little is known concerning the vapor pressure of soil moisture.[13] It may be expected, however, to vary with the shape of the film surfaces, with the surface tension, with the thickness of the film, and with the concentration of the solutes present. If, by a change in any of these conditions, the vapor pressure of the soil moisture about the roots is lowered below that of the surrounding soil, there will be a movement of water vapor toward the plant roots, and then a condensation. More than this, the water which permeates the plant roots together with their root hairs has a vapor tension and thus the roots must either give off water in the form of vapor or take it in, as they are in an atmosphere with a vapor tension either lower or higher than that of their own moisture. The common practice of growing plants in a damp chamber is evidence of this.

In the above-described experiments, the air cavities, in the quartz, were lined with projecting root hairs, which were often so numerous as to give the cavity the appearance of having walls covered with a delicate fur coat.

The writer has undertaken some further experiments in regard to the relation of plants to vapor tension; while no numerical results have been obtained, the preliminary experiments show that plant roots are very sensitive to variations in vapor pressure.

In regard to the influence of the concentration of soil moisture upon vapor tension and water transfer, the following experiment

has been completed. Five tall glass tumblers were selected, and 100 grams of dry river sand placed in the bottom of each tumbler. The sand in tumblers 1 and 2 was moistened with 10 grams of distilled water. To the sand in tumbler number 3, 10 grams of a 5 per cent. solution of sodium chloride were added. The sand in tumbler 4 was wetted with a 15 per cent. solution, and the sand in number 5 with 10 grams of a 20 per cent. solution of the same salt. A cloth diaphragm was then fixed in each tumbler, 3 centimeters

FIGURE 1. Apparatus for showing the influence of salt on vapor transfer in soils. Description in text.

above the sand, thus leaving a free air-space between it and the sand. One hundred grams of sand were placed upon the cloth diaphragms of each of the tumblers. This sand, in all of the tumblers except tumbler number 2, was moistened with 10 grams of distilled water. Tumbler number 2 had 10 grams of a 10 per cent. salt solution added to the sand above the diaphragm. After being sealed by tying sheet rubber over the top, the tumblers were then set in the basement, where there was but very slight variation in temperature (at least not more than occurs in field soils). After 10 days they were opened, and the amounts of water in the two layers of sand determined. As shown in the table, there

was, in every case, a transfer of water to the soil containing the salt solutions. Moreover, the transfer was made, by water in the form of vapor, across the air space. The water moved from the region of higher vapor pressure to the region of lower vapor pressure, and then condensed.

No.	Solution added below.	Solution added above.	Transfer of water in grams.	Direction of transfer.
1	Dis. H_2O	Dis. H_2O	1.35	down
2	"	10 per cent. NaCl	2.17	up
3	5 per cent. NaCl	Dis. H_2O	2.40	down
4	10 per cent. "	"	3.85	"
5	20 per cent. "	"	5.95	"

It will be noted that, in tumbler number 1, with distilled water both above and below the diaphragm, there was a transfer downward. This was probably due to the weight of the column of vapor in the glass. This difference was further shown by the difference in results from tumblers 2 and 4, where the condition in tumbler number 2 was the inverse of the condition in tumbler number 4, the salt solution being above the diaphragm in number 2, and below the diaphragm in number 4. In tumbler number 2, the water was transferred against the pull of gravity, while in tumbler number 4 the transfer was with the pull of gravity. As expected, the amount of transfer in number 4 was greater than that in number 2. It is possible that water condensed in drops on the sides of the glass and, in some cases, ran down. This error, however, is not very large, and could not explain the results of number 2, nor the regular curve which all the results produce when plotted. Furthermore, there was no visible evidence of such a transfer. The amount of transfer in number 3, which had a concentration of soil moisture of the same magnitude as that of my cultures some time before the plants wilted, would have been sufficient to have raised the percentage of soil moisture to within the limits of available water.

CONCLUSIONS

1. In these experiments, it has been shown that the amount of non-available water is not influenced by adding to pure quartz the quantities mentioned above of either sodium chloride or the salts of a full nutrient solution.

2. Practically all plants of economic value are land plants, and hence, for both their water and food supply, are dependent on water

films. Therefore, it is important that we understand the conditions of equilibrium between the plant and this form of water.

3. It is apparent that the isotonic values determined for substances dissolved in free water do not necessarily hold for film-water. We cannot thoroughly understand the acquisition of water and food by land plants, or the results from fertilizer experiments until some of these values are known. Further, the conditions of equilibrium *in film water* must be determined for both toxic and "balanced" solutions, before we have reached a logical stopping place for these lines of research.

4. The investigations should be carried out with carefully controlled experiments, in which the number of unknown factors is reduced to a minimum. Fundamental principles will scarcely be demonstrated by experiments on soils chosen at random in the field. Such soils contain too many unknown factors. Experience shows that experiments from soils from the same locality may not yield comparable results. The soil used should be of simple composition, and its content known. We must have a number of simple standardized soils, of which samples can be duplicated. I have used a soil with comparatively few unknown factors, and one that is to be had in practically unlimited amounts. These experiments can be duplicated.

5. Much of our knowledge of the relation of plants to the soil must be obtained by indirect methods. A great deal of it must be worked out in the laboratory of the physical chemist. But all such results should be checked up by experiments with the plant itself, for the problem of the relation of plants to the soil is primarily a problem in botany, both in its inception and final solution.

The greater part of this work has been done under the direction of Professor C. Stuart Gager, whose suggestions and encouragement have been invaluable in its prosecution.

DEPARTMENT OF BOTANY,
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The embryo-sac of Pandanus coronatus

DOUGLAS H. CAMPBELL

The Pandanaceae are generally regarded as one of the lowest families of the monocotyledons. For this reason it seemed worth while to examine the embryo-sac to determine whether it showed any evidence of primitive characters in its structure.

Material was collected in Java in 1906, and a preliminary examination showed very marked departure from the ordinary angiospermous type. An account of the results of this investigation has already been published.*

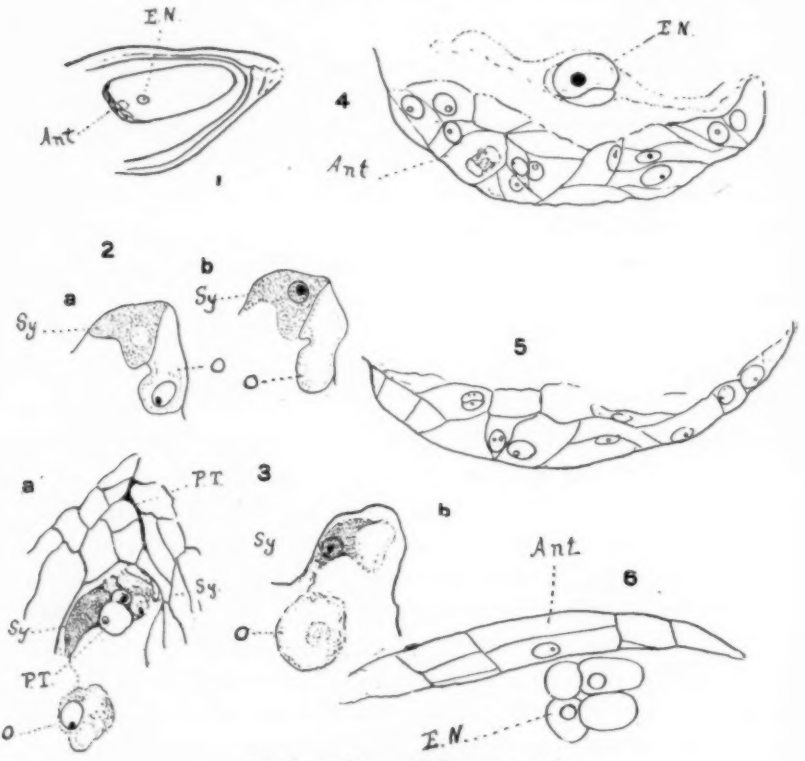
The oldest stages secured from my Javanese material showed fourteen nuclei in the embryo-sac instead of the eight nuclei found in typical angiosperms. Of the fourteen nuclei, two were at the micropylar end of the sac, the others at the chalazal end. It was impossible to tell whether this stage represented the condition at the time of fertilization, and further efforts were made to obtain material which would settle this important question.

Through the kindness of Dr. W. R. Shaw, of Manila, I have received a large amount of material, very carefully preserved, which has furnished the stages of development that were desired. Dr. Shaw writes that the species is probably *P. coronatus* Martelli —a name supposed to be synonymous with *P. tectorius* Soland. Preparations made from this material showed a number of instances in which the pollen-tube was entering the embryo-sac, and a comparison of these with the latest stages found in the material from Java showed that the latter were by no means mature.

Pressure of other work has made it impossible at this time to present a detailed account of the development of the later stages of the embryo-sac, but it is hoped later to prepare a full account of the development both of the embryo-sac and embryo. The present note is intended to give a description only of the structure of the embryo-sac at the time of fertilization.

*Bull. Torrey Club **36**: 205–220. *pl. 16, 17.* 1909.

FIGURE 1 shows a section of an ovule containing the nearly mature embryo-sac. At the micropylar end is a nearly typical egg-apparatus consisting of two synergids and the elongated egg, *o*. These are shown more enlarged in FIGURE 2. At the chalazal end is a large discoidal mass of cells, the antipodal cells, the exact number of which was not ascertained, but it probably is variable. Above the antipodal tissue are two large free nuclei which probably



Explanation of figures 1–6

1. A nearly median section of an ovule of *Pandanus coronatus*, shortly before fertilization. × about 35.

2. Two sections of the egg-apparatus from the same embryo-sac, × 320; *Ant.*, antipodal cells; *E.N.*, polar nucleus; *Sy*, synergid; *o*, egg-cell.

3. *a*. Upper part of a somewhat older ovule, showing the entrance of the pollen-tube, *P. T.*, × 320. *b*. The second synergid and egg from the same.

4, 5. Two sections of the antipodal cells from the embryo-sac shown in fig. 2. There were three "polar" nuclei, *E. N.*

6. Antipodal region from an embryo-sac with six polar nuclei, of which four are shown in the figure.

represent the polar nuclei of the ordinary embryo-sac. In this specimen the pollen-tube had not yet reached the nucellus.

Several somewhat older stages were also examined, some of which showed the entrance of the pollen-tube. In FIGURE 3 the pollen-tube is seen within the embryo-sac—where it has partially destroyed one of the synergids. Two small nuclei, probably the generative nuclei, could be seen within the pollen-tube. The egg, *o*, lay some distance below the synergids, but this was probably due to displacement in mounting the sections. Two sections of the antipodal region are shown in FIGURES 4 and 5. There were three polar (?) nuclei, apparently in process of fusion.

In another specimen (FIGURE 6) there were six "polar" nuclei.

It is thus evident that at the time of fertilization, the embryo-sac of *Pandanus* has a very much larger number of cells than that of the typical angiosperms, this being shown both in the increased number of antipodal cells, and that of the "polar" nuclei.

It still remains to be seen what is the relation of the "polar" nuclei to the egg-apparatus and to the antipodals.

The embryo-sac of *Pandanus* most nearly resembles that of *Sparganium*, but in the latter the increased number of antipodal cells arises subsequently to fertilization, and there are but two polar nuclei. The structure of the embryo-sac tends to confirm the view that the families Pandanaceae and Sparganiaceae are really closely related. (See arrangement of the families of monocotyledons in Engler & Prantl, Die Natürlichen Pflanzenfamilien.)

STANFORD UNIVERSITY,
CALIFORNIA.

Some new Hawaiian plants

JOSEPH F. ROCK

Pittosporum Hosmeri Rock

Arbor 6.5–10 m. alta, ramis robustis; folia coriacea, 90–125 mm. longa, 18–38 mm. lata, oblanceolata, obtuse acuminata, supra glabra, subtus lanuginosa, petiolo tomentoso 12–25 mm. longo; capsulae maturae 3 aut 4 in pedunculo 12–20 mm. longo, lignosae, glabrae, oblongo-subquadrangulatae, 55–75 mm. longae, 45 mm. latae; semina nigra, rugosa, 6–7 mm. diam.

A tree 6.5–10 m. high, with a straight trunk and rather stout branches, young shoots pubescent; leaves crowded at the ends of the branches, coriaceous, 90–125 mm. × 18–38 mm., oblanceolate, bluntly acuminate, the upper side glabrous and wrinkled with a close net-work, covered underneath with a silvery gray wool, entire, gradually narrowing into a pubescent petiole of 12–25 mm.; open mature capsules single or 3 or 4 on a woody peduncle of 12–20 mm. and pedicels of 2 mm., thick-woody, oblong to subquadrangular, 55–75 mm. × 45 mm., opening into two, three, or sometimes four valves with a longitudinal median groove, glabrous when old, covered with a grayish brown wool when young; endocarp bright orange-colored, seeds black, rugose, 6–7 mm. in diameter. The fruits exude a milky glutinous sap. Flowers not collected. [FIGURE 1.]

This tree is rather common on the lava fields of Puuwaawaa, Hawaii, at an elevation of 3,000 feet. The species is remarkable for the unusually large woody capsules which open into two, three, and sometimes four valves. (Native name Aawa hua kukui.)

The type number is 3957 in the herbarium of the Board of Commissioners of Agriculture and Forestry, Territory of Hawaii. Collected at an elevation of 3,000 feet. (*J. F. Rock*, June 17, 1909.)

Named in honor of Mr. R. S. Hosmer, Superintendent of Forestry, Hawaii.

Sideroxylon rhynchospermum Rock

Arbor 10–20 m. alta; folia coriacea, obovato-oblonga, 14–18 cm. longa, 4.5–8 cm. lata, petiolo 2.5–3 cm. longo, alterna, stipulis 0, prorsus glabra, folia novella tomentosa; calyx fere usque ad basin partitus, segmentis 5, acuminatis, imbricatis; corolla lutea,

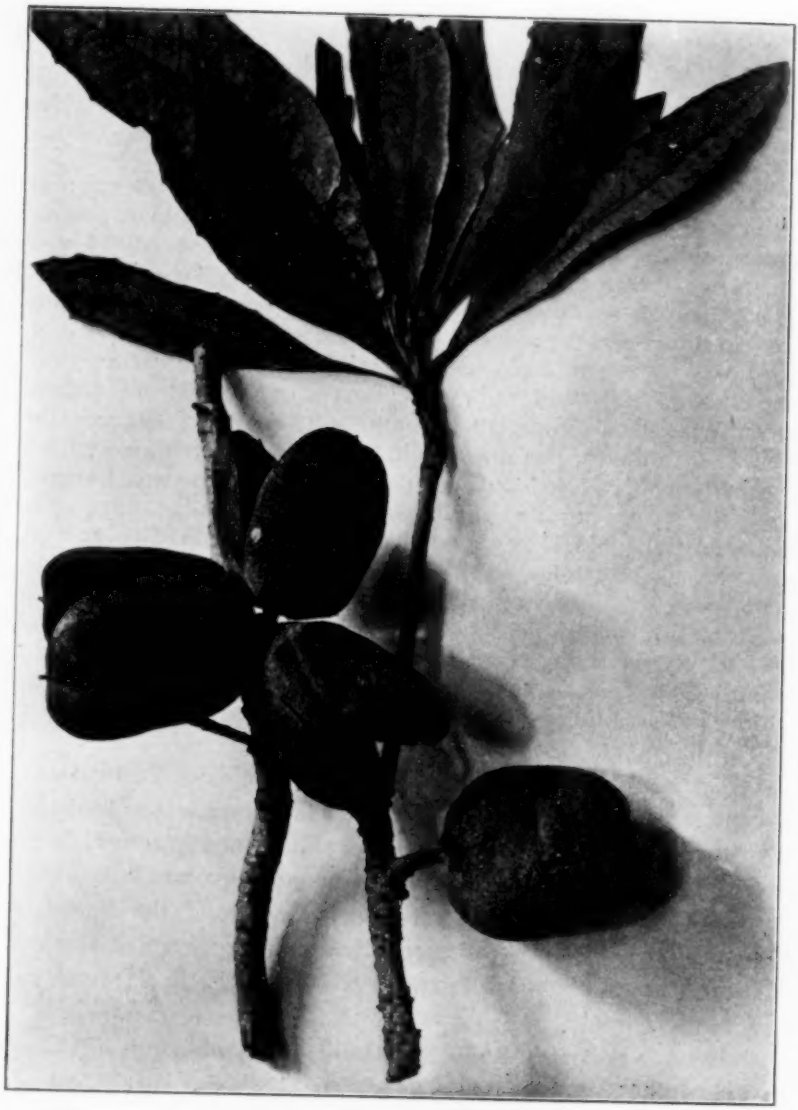


FIGURE 1. *Pittosporum Hosmeri* Rock. Slightly less than one half the natural size.

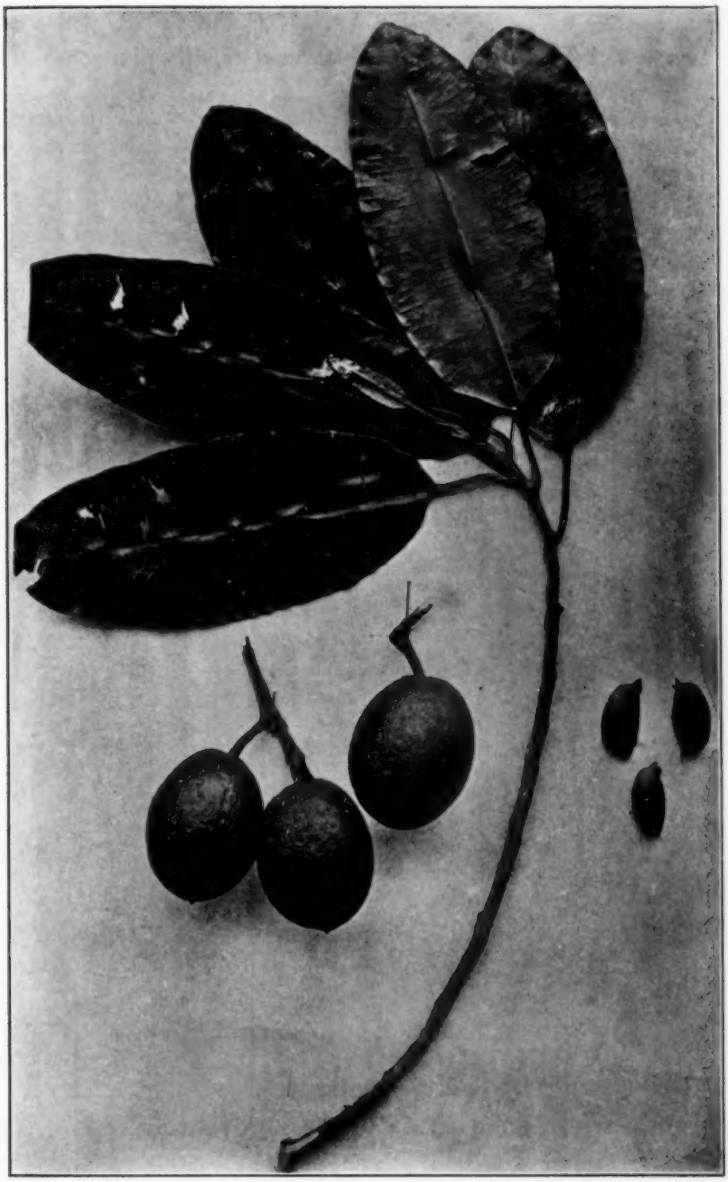


FIGURE 2. *Sideroxylon rhynchospermum* Rock. Showing foliage, fruit, and seeds. Two fifths the natural size.

campanulata, lobis 5; stamina glabra, ad basin corollae affixa; stylus brevis; bacca ovoidea, purpurea vel nigra, 4.5–5.5 cm. × 3.5–4 cm.; semina 3–5, testa crustacea nitida, plana, rostrata, 25–30 mm. longa, 12–14 mm. lata.

A tree 10 m.–20 m. high, dividing freely into ascending branches; bark brownish, with shallow, narrow longitudinal corrugations about 3 mm. thick, trunk up to 45 cm. in diameter four feet from the ground; leaves coriaceous, obovate-oblong, 14–18 cm. × 4.5–8 cm., on petioles of 2.5–3 cm., alternate, estipulate, quite glabrous with age, some pubescence remaining on the sides and angles of the midrib and veins, especially on the lower surface, shining above, dull beneath, midrib prominent, with lateral veins leaving midrib at wide angles (about 80° in center of leaf) parallel to margin and connected by a continuous intra-marginal nerve, young leaves densely covered with appressed brown hair on both surfaces; flowers in clusters 2 or 3 (?) on tomentose pedicels, 12–20 mm. long; calyx 5-parted to near the base, lobes imbricate, acuminate, 3–5 mm.; corolla light yellow, longer than the calyx, 4–5-parted to the base, the lobes acute; staminodia half as long as the lobes, linear, with a faint nerve; stamens 5, inserted at the base of the corolla, glabrous; anthers erect, ovate, the cells confluent at the apex, opening laterally; ovary hirsute, 5-celled, style short-conical; fruit a purple or black plum-like berry 4.5–5.5 cm. × 3.5–4 cm., rather fleshy, 3–5-seeded; seeds enclosed in a papery pyrena, 25–30 mm. × 12–14 mm., flat, beaked at both ends of the ventral angle, which is occupied by the scar of the raphe, the crustaceous testa thin, of a light brown color. [FIGURE 2; FIGURE 3, *a*, *b*.]

This tree was discovered by Dr. H. L. Lyon, pathologist of the Hawaiian Sugar Planters' Experiment Station, in the woods of Nahiku, Maui, at an elevation of 1,300 feet, where he collected the type material. Dr. Lyon observed one large tree at Kailua, Maui, which had a straight trunk fully 30 feet to the first branch.

The type is number *6061*, given by Dr. Lyon for the herbarium of the Board of Commissioners of Agriculture and Forestry, collected January 15, 1909, at Nahiku, Island of Maui.

Lysimachia glutinosa Rock

Frutex 10–12 dm. altus; folia alterna, chartacea, obovato-oblonga, acuminata, 38–102 mm. longa, 12–30 mm. lata, petiolis longitudine 12 mm.; pedicelli axillares, ex axillis foliorum superiorum; calyx fere usque ad basin partitus; corollae rotato-campanulatae, albae, lobis 5–8, ovatis; capsula lignosa, ovata, 5–10 valvis dehiscens; semina numerosa.

A diffusely branching shrub 10–12 dm. high, glutinous; leaves alternate, chartaceous, entire, obovate-oblong, acuminate, 38–102 mm. × 12–30 mm., narrowing into a winged petiole of 12 mm., upper

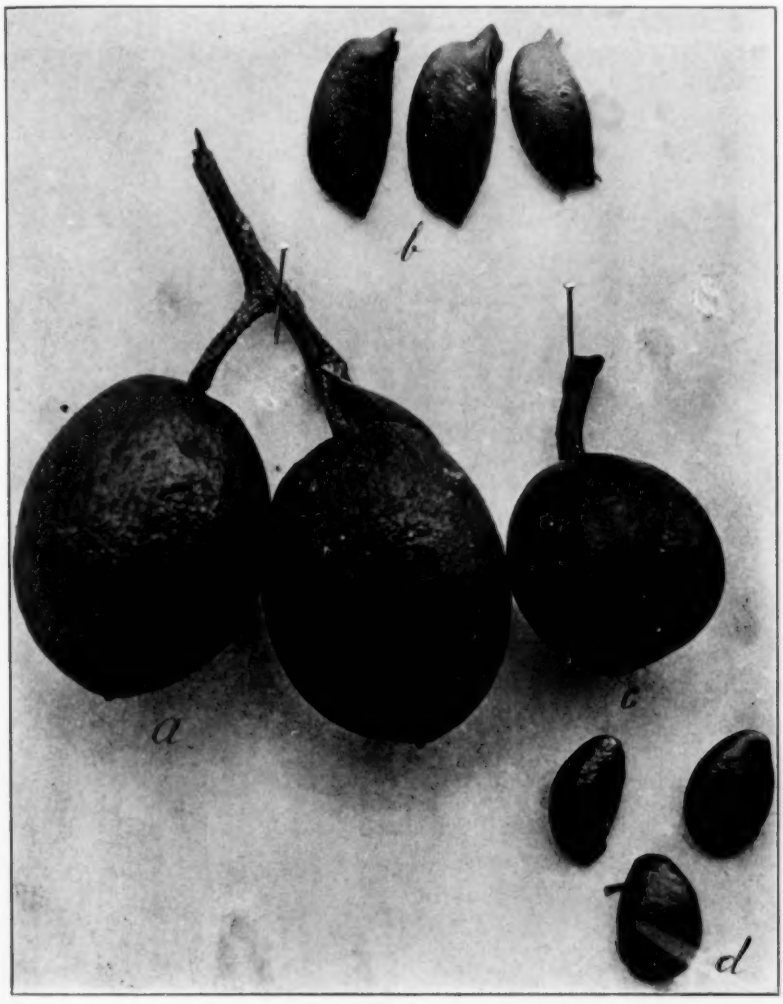


FIGURE 3. *a, b, Sideroxylon rhynchospermum* Rock.; *c, d,* fruit and seed of *S. sandwicense* Benth. & Hook., introduced for comparison. Slightly reduced.

face covered with a glutinous exudation, underneath glabrous and pale with prominent nerves; inflorescence viscid; flowers solitary in the axils of the upper leaves on pedicels of 38 mm. (50–76 mm.

when with fruit); calyx persistent, with ovate-lanceolate acute lobes free to near base, and half the length of the corolla, punctate; the imbricate corolla large, rotate-campanulate, cream-colored, 25–38 mm. in diameter, cut deeply into 5–8 ovate lobes, tube 4 mm. long; stamens half the length of the corolla or little more, the rather long filaments united at the base by a granular membrane,

FIGURE 4. *Lysimachia glutinosa* Rock. One half natural size.

anthers erect; style little shorter than the stamens; capsule ovoid, smooth, 12 mm. or more long, lignescent, glossy inside, opening by 5–10 valves; seeds numerous. [FIGURE 4.]

This plant is sometimes covered with hair, flies, and dirt, which adhere to the very viscid inflorescence and leaves; the large showy

flowers are of striking beauty (February to March). In the herbarium the dried specimens leave large oil spots on the paper.

The type is number *1770*, in the herbarium of the Board of Agriculture and Forestry of the Territory of Hawaii, collected on

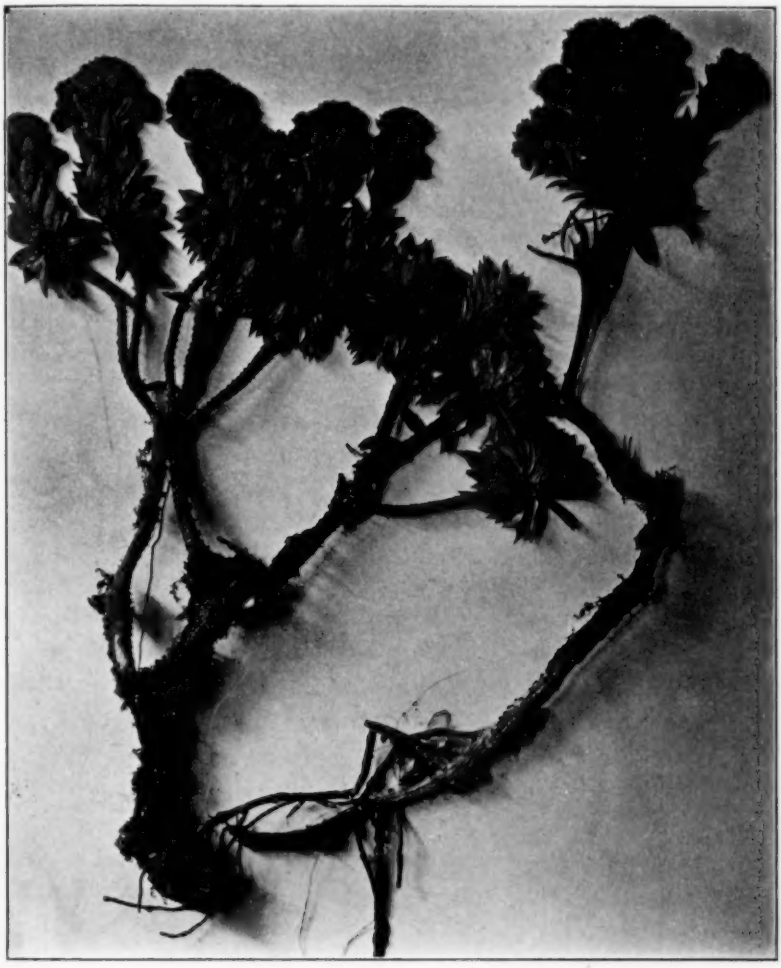


FIGURE 5. *Dubautia Waialealae* Rock. Slightly less than one half the natural size.

the highest ridge west of Halemano, Kauai, on rather open places at an elevation of 4,500 feet (February 14, 1909). A few shrubs were seen in the woods back of Kalalau.

Dubautia Waialealae Rock

Planta hirsuta, 2–3 dm. alta; folia coriacea, 15–20 mm. longa, 4–6 mm. lata, terna, sessilia, oblanceolata; capitula 5–10 mm. diam., hirsuta, in pedicellis 4–27 mm. longis; corymbus foliaceus; involucrum angustum, bracteis 5–6; receptaculum conicum, hirsutum, paleis 14–18; corollae luteae; pappi paleae lanceolatae, ciliatae; achaenia parce pilosa.

Whole plant hirsute, 2–3 dm. high, with stout woody branches covered with leaf-scars throughout; leaves thick-coriaceous, crowded, 15–20 mm. × 4–6 mm., ternate, sessile, oblanceolate, acute, narrowing below, remotely denticulate in the upper half, covered with small stiff whitish hairs on both sides, many-nerved; flower-heads 5–10 mm. in diameter, hirsute on pedicels of 4–27 mm. in groups of 4–18 at the ends of the branches, corymb foliaceous; involucral bracts 5 or 6, almost as high as the heads; receptacle conical, covered with long white hairs, paleae 14–18; florets 6–30; corolla bright yellow, slightly exserted, deeply 5-cleft, lobes reflexed; pappus chaffy, the narrow lanceolate ciliate paleae as long as the hispid straight achenes.

The type number is *5030* in the herbarium of the Board of Agriculture and Forestry of the Territory of Hawaii; collected (September 24, 1909) at the summit of Mt. Waialeale, Kauai, at an elevation of 5,250 feet, where the plant grows in company with *Geranium humile*, *Lobelia kauaiensis*, *Pelea Waialealae*, and *Drosera longifolia*.

BOARD OF AGRICULTURE AND FORESTRY,
HONOLULU, HAWAII.

A new fossil fucoid

ARTHUR HOLLICK

(WITH PLATE 33)

Among a number of unidentified specimens recently subjected to critical examination in connection with the work of arranging the paleobotanical museum of the New York Botanical Garden, was one of an unusually well-defined, almost perfect frond of a fucoid. The original label reads "*Haliserites* sp. (near *H. Dechenianus* Göpp.). Devonian. Franklin, Delaware Co., N. Y."; but neither the name of the collector nor the date of collection is recorded.

The locality indicated is within the Devonian area of the state, and the specimen, if dismembered, would resemble very closely, in its parts, certain Devonian fucoid remains from the same general region, referred to the genus *Haliserites* by D. P. Penhallow.* In the paper cited a number of fragmentary specimens are described and figured under the names *Haliserites Dechenianus* Göpp., *H. Dechenianus lineatus* var. nov., and *H. lineatus* sp. nov. They apparently merely represent different parts of a single species, and if all were combined the combination would resemble quite closely a portion of the specimen now under consideration. They are all described as having dichotomously forked branches—the only specific differences being the characters described, respectively, as "equally and strongly costate throughout," "midrib well-defined throughout" and "costate throughout, costa not prominent." The figures, however, fail to show these latter characters in a satisfactory manner in any instance and none of them gives any idea of the size or shape of the frond. Under the circumstances, therefore, it would be inadvisable to assume specific identity between our specimen and any one or all of these fragmentary remains, although it would be entirely justifiable to regard them as identical generically.

*Notes on Erian (Devonian) plants from New York and Pennsylvania. Proc. U. S. Nat. Mus. **16**: 105–114. *pl. 9–14.* 1893.

Another contribution dealing with the same subject is by David White,* in which two fine specimens, more or less closely resembling ours in general aspect, are described and figured under the new generic and specific name *Thamnocladus Clarkei*, and he remarks (p. 598) that "the fossils of the species here described as *Thamnocladus clarkei* have generally been recorded in American literature under the name *Haliserites dechenianus* Göpp." He regards such specific identification as doubtful, however, and contends, with excellent reason, that in any event none of the specimens of this species, European or American, should be referred to the genus *Haliserites* as originally described and figured by Sternberg,† and then proposes (p. 603) the generic name *Taeniocrada* to include the American forms referred by Penhallow to *Haliserites* and also certain similar European species of the genus (*H. distans* Eichw. and *H. lusaticus* Gein.), but is doubtful about including the specimens figured by Göppert as *H. Dechenianus*. The type species of the genus *Taeniocrada* is stated to be *T. Lesquereuxii* David White MSS. (no. 25164, Lacoe collection, U. S. Nat. Mus. Catskill beds, Factoryville, Pa.), represented by Penhallow's *f. 6 pl. 10* (*loc. cit.*), under the name *Haliserites Dechenianus* Göpp.

Apparently it was White's intention to maintain the two genera, *Thamnocladus* and *Taeniocrada*, as distinct, but if so his intention is not very clearly expressed and is liable to be misinterpreted. It may also be pertinent to remark that it is entirely a matter of personal opinion whether or not they should be so regarded, and, from a careful consideration of all the available evidence, I am inclined to the opinion that the facts do not warrant their separation.

If, therefore, we regard all of Penhallow's specimens as representing a single species, and accept White's view that this species is probably not *Haliserites Dechenianus* Göpp., and his conclusion that, in any event, it can not belong in the genus *Haliserites* Sternb., the questions to be decided are, first, whether or not our specimen is identical with any species heretofore described, and

*Description of a fossil alga from the Chemung of New York, with remarks on the genus Haliserites Sternberg. Rep. N. Y. State Paleontologist **1901**: 593–610. *pl. 3, 4.* 1902.

†Fl. Vorwelt **2**: 34. *pl. 24. f. 7.* 1833.

second, under what generic name it should be placed in order that it may conform to accepted rules of nomenclature.

Taking all of the facts and circumstances into consideration, it seems advisable to describe our specimen under the name

Thamnocladus passifrons sp. nov.

Frond irregularly branching from a short expanded base, apparently flat throughout and somewhat extended laterally, surface smooth and shining; branches dichotomously forked at varying intervals, mostly incurved above each bifurcation, gradually diminishing in width from about 5 mm. below to 1 mm. at the ultimate extremities, obscurely costate in places; costae median?

In red shaly sandstone.

Devonian (Catskill group), Franklin, Delaware County, New York.

Type in the museum of the New York Botanical Garden.

Explanation of plate 33

Thamnocladus passifrons Hollick. From a photograph of the type specimen, natural size.

The name Buthotrephis gracilis Hall

EDWIN W. HUMPHREYS

While engaged in the work of identifying and naming certain of the specimens in the paleobotanical museum of the New York Botanical Garden my attention was called to the confusion that obtains in connection with the use of the name *Buthotrephis gracilis* Hall; and in the hope of establishing hereafter the correct application of this name it has been deemed advisable to present the following account of its origin, together with a brief discussion of the principles of nomenclature that are involved with it:

In 1843 Hall* described and figured a fossil fucoid from the Clinton group, under the name *Fucoides gracilis*.

In 1847† he described and figured a similar fossil from the Trenton limestone, under the name *Buthotrephis gracilis*.

In 1852‡ he described and figured another specimen from the Clinton Group under the name *Buthotrephis gracilis*, and included with it, as a synonym, his *Fucoides gracilis*, followed by the note "Not *B. gracilis*, Pal. N. York, Vol. 1, pag. 62, pl. 21, fig. 1. The species of the Clinton group will retain this name by precedence, and that of the Trenton limestone may be changed to *B. tenuis*."

From a consideration of the above facts it may be appreciated that in common usage the name *Buthotrephis gracilis* Hall might be meant to indicate either one of the two species which Hall regarded as distinct from each other and as representing two distinct and rather widely separated geologic horizons. A critical study of literature relating to the subject has shown this to be the case and, further, that the changes in nomenclature suggested by Hall have received but scant attention on the part of most writers. These conditions have, in consequence, led to more or less confusion, and to considerable doubt in many instances as to which species is meant where a fossil fucoid is referred to as *Buthotrephis*

*Nat. Hist. N. Y. Pt. IV. Rept. Fourth Geol. Dist. 69. *f. 14.*

†Ibid., Pt. VI, Paleont. N. Y. **1**: 62. *pl. 21. f. 1.*

‡Ibid., Pt. VI, Paleont. N. Y. **2**: 18. *pl. 5. f. 1a–1d.*

gracilis Hall. This is especially true in the case of local lists of fossils, as for instance in such a list from the Trenton limestone of any locality, in which the name may be found included, without comment or adequate description, and the intention of the author of the list can only be inferred. The probability, of course, is that he is referring to the Trenton limestone species, but on the other hand he may be announcing the discovery of the Clinton *B. gracilis* in the Trenton limestone. Hence it is frequently more or less hazardous to draw conclusions in regard to the areal or stratigraphic distribution of the species recognized as *Buthotrephis gracilis* from such lists or other similar publications.

In this connection, as an indication of the extent to which the application of correct nomenclature has been disregarded, the following data may be of interest:

In sixty-five references to *Buthotrephis gracilis* Hall, twenty-three were found to refer more or less clearly to the Trenton species and twenty-four to the Clinton species, while in regard to the remaining eighteen it was impossible to hazard more than a guess as to which species the author had in mind. From among all of these references, therefore, more than one fourth were useless as a basis for accurate conclusions or inferences.

In twenty-six references to what was clearly intended to mean *Buthotrephis tenuis* Hall, twenty-three referred to it as *B. gracilis*, but fortunately with more or less plain indications as to which species was meant, while in the three remaining references only was it called *B. tenuis*.

Finally, attention is called to the fact that in accordance with our accepted rules of nomenclature the binomial *Buthotrephis gracilis* Hall, 1847, by reason of priority of publication, must be applied to the Trenton species, and the name *B. tenuis*, which he subsequently proposed for it, in 1852, becomes merely a synonym. Further, his transfer of the Clinton species, *Fucoides gracilis*, to the genus *Buthotrephis*, in 1852, required that this species be renamed, for the reason that the original specific name, *gracilis*, had been previously combined with *Buthotrephis* to represent the Trenton species. As this has not heretofore been done, so far as I am aware, the name *Buthotrephis Hallii* is now proposed for the Clinton species, in honor of the founder of the genus.

The synonymy of the two species may therefore be given as follows:

Buthotrephis Hallii nom. nov.

Fucoides gracilis Hall, Nat. Hist. N. Y. Part IV, Rept. Fourth Geol. Dist. 69. *f. 14.* 1843.

Buthotrephis gracilis Hall, ibid., Part VI, Paleont. N. Y. **2**: 18. *pl. 5. f. 1a–1d.* 1852. Not *B. gracilis* Hall, ibid. **1**: 62. *pl. 21. f. 1.* 1847.

BUTHOTREPHIS GRACILIS Hall

Nat. Hist. N. Y. Part VI, Paleont. N. Y. **1**: 62. *pl. 21. f. 1.* 1847.

Buthotrephis tenuis Hall, ibid. **2**: 18 [note under synonymy]. 1852.

Studies on the Rocky Mountain flora — XXII

PER AXEL RYDBERG

ERIGERON

Just as the writer resumed his work on *Erigeron*, Coulter and Nelson's New Manual of Botany of the Central Rocky Mountains came out. From all evidences it is apparent that most of the work in connection with the new book has been done by Professor Aven Nelson, of the University of Wyoming. The work is a great improvement on the old Coulter's Manual and it is perhaps the best manual that has been put out treating on the botany of the West. It has, however, many features to which the present writer is unwilling to subscribe. Dr. B. L. Robinson in his recent review* has pointed out the unevenness in the nomenclature, in that the Vienna Code has been followed in some cases, in other cases not. But this is easy for me to understand, for Professor Nelson has until lately followed the "Rochester Code," and it is not so easy to change the nomenclature of one's thinking and writing and make it self-consistent.

A few years ago, when Professor Nelson published his "New Plants from Wyoming" in the Bulletin of the Torrey Botanical Club, he was about as "radical" as the present writer, and had about the same limitation of species. If we should judge from the New Manual, his conception of a species seems to have changed considerably, as seen from the number of specific names reduced to synonymy. Whether this change of attitude has slowly grown upon Professor Nelson or is due to influence from his collaborators, I can not tell. There is, however, one feature in this connection that seems to me somewhat unexplainable. Professor Cockerell in his review† of the book stated:

"I have had the curiosity to count the number of species admitted as valid in the new manual, which were undescribed at the time of the publication of the first edition in 1885. They

*Rhodora **12**: 13–16. Ja 1910.

†Science II. **31**: 302. 1910.

number 787, about 28 per cent. of the whole flora . . . Of the 787, no less than 244 were proposed by Professor Aven Nelson himself; 152 are by Dr. Rydberg, of the New York Botanical Garden, and 148 by Dr. E. L. Greene, now of the U. S. National Museum, but at one time a resident of Colorado. . . . The number of species accepted as valid is 2,733, while no less than 1,788 specific names are rejected as synonyms or insufficiently known. Many of those latter were proposed by Professor Nelson himself, more by Rydberg and Greene."

Why should more (nearly 66 per cent. more) of Professor Nelson's species be acceptable and "many more" of Dr. Greene's and my own be reduced to synonymy? Not counting the time before the first edition of the Manual of the Rocky Mountain Region appeared, Dr. Greene published on the flora for ten years, between 1885 and 1895, when practically no work was done by Professor Nelson or myself, and he has published at least twice as many new species from the Rocky Mountain Region as Professor Nelson. Both Dr. Greene and myself have had access to much larger herbaria and libraries than has Professor Nelson, and have seen specimens from the Rockies which he has not seen. The New Manual, therefore, seems to show a decided partiality for the species proposed by Professor Nelson himself. Some partiality would be expected, but in this case it seems out of proportion. Professor Nelson is a very conscientious worker, and it would be unjust to claim that this imparity in treatment was intentional. The main cause, I think, is that he had not seen the types or authentic material of many of the species so reduced. He knew his own species, but not all of those proposed by other botanists. It was not fair to them simply to reduce their species to synonymy, if such species were unknown. If question-marks had been added to show probable synonymy, the matter would have been improved considerably. There are many cases in which I am confident that Professor Nelson had no specimens illustrating species reduced to synonymy.

Some years ago I spent considerable time on *Erigeron* as repreented in the Rockies and had seen the type or a duplicate of the type of nearly every species described. In fact, I knew the genus (one of the largest in the region) as well as any of the composite genera. That I should have resumed the work on that genus just

as I received the New Manual was a curious coincidence. There is scarcely a genus, in which I, from my standpoint, could pick out so many flaws of treatment in the New Manual. This paper, therefore, has become an adverse criticism of the New Manual, more so than I had intended or wished.

The way in which the authors of the New Manual have determined what species should be regarded as good and which names should be reduced to synonymy, is rather interesting. Many of Dr. Greene's species and my own have been reduced, while others of older authors and of Nelson's have been kept up. The uneven treatment, as I have said before, is due in some cases to the fact that the authors had not seen the types. *Erigeron lapiluteus* A. Nels. (*E. yellowstonensis* A. Nels.) is regarded as distinct from the exceedingly close *E. droebachensis*, and *E. trifidus* from *E. compositus;* while *E. jucundus* Greene is made a variety of the little related *E. acris* L., *E. multifidus* Rydb. is made a synonym of *E. compositus*, and *E. flabellifolius* Rydb. one of *E. trifidus*. The fact is that *Erigeron multifidus* Rydb. is much closer to *E. trifidus* than to *E. compositus* and grades directly into it. The typical *E. compositus* is rare and more distinct. I think, though, that they are all three forms of one species, while *E. flabellifolius* has nothing to do with either. It has a stoloniferous rootstock instead of a cespitose caudex and the leaves do not at all suggest *E. trifidus* but are more like those of *Ranunculus Eschscholtzii* in outline.

Erigeron conspicuus Rydb. is made a synonym of *E. speciosus* DC. In the herbarium of Columbia University there is a duplicate of the type of *E. speciosus* DC., collected by Douglas. In this the stem and leaves are perfectly glabrous except the ciliate margins of the latter and the plant is closely related to *E. macranthus* Nutt., perhaps not distinct. *E. conspicuus* Rydb. is considerably hairy on both the stem and the leaves, and if reduced should be included in *E. subtrinervis* Rydb. rather than in *E. speciosus*. If the type of *E. conspicuus* were placed before a student and he used the key of the New Manual, it would be named *E. subtrinervis*.

Both *Erigeron salicinus* Rydb. and *E. platyphyllus* Greene are made synonyms of *E. macranthus* Nutt. While the first is

closely related to that species, the second can scarcely be said to be so. Its habit, foliage, and pubescence are those of *E. subtrinervis* and only the involucral bracts are those of *E. macranthus*.

Erigeron incanescens Rydb., *E. eximius* Greene, and *E. viscidus* Rydb. are all made synonyms of *E. formosissimus* Greene. The first has a hirsute involucre and is related to *E. subtrinervis;* the third and fourth have glandular-puberulent involucre and may well be united. The authors have included *Erigeron formosissimus* also among the annuals or biennials, though it is evidently a perennial. The third has also glandular involucres, but is almost glabrous and should have been included in *E. asper* of the New Manual if reduced.

Erigeron glabellus Nutt., *E. consobrinus* Greene, *E. oblanceolatus* Rydb., and *E. Earlei* Rydb. are made synonyms of *E. asper* Nutt. *E. glabellus* and *E. Earlei* have perennial branched rootstock; the rest are biennial with tap-roots. They may perhaps sometimes be perennial, but there is no evidence of a branched rootstock. In *E. glabellus* the pubescence is spreading, in *E. Earlei* closely appressed.

Erigeron nematophyllus Rybd. is made a synonym of *E. Eatonii* A. Gray. The latter is not uncommon in Utah, where I have collected it myself. A duplicate of the type is in the Columbia University herbarium. It has narrowly linear-oblanceolate, distinctly triple-nerved basal leaves and decidedly flattened achenes. In *E. nematophyllus* the leaves are almost filiform and strictly one-nerved. Evidently Professor Nelson did not know *E. Eatonii*, for what he has distributed under that name is *E. nematophyllus*. The only specimens of the real *E. Eatonii* from Wyoming in our collections are from Wind River Mountains, and there collected by Merrill & Wilcox and by Tweedy.

Erigeron curvifolius Piper is made a synonym of *E. luteus* A. Nels., although they are not closely related, the former being a coarsely hirsute plant, with leafy stem, the latter being a closely strigose subacaulescent plant. It would have been much better to reduce Nelson's own *E. luteus* to a synonym of *E. peucephyllus* A. Gray, to which it is closely related.

Erigeron Parryi Canby & Rose, *E. Scribneri* Canby, and *E.*

vetensis Rydb., are made synonyms of *E. radicatus*. *E. vetensis* has an involucre of two series of subequal bracts, a simple pappus, consisting of bristles only, of which some are occasionally shorter. Both *E. Parryi* and *E. Scribneri* have 3 or 4 series of bracts, more imbricated and more flat, obovate-cuneate achenes and double pappus, the outer squamellate. Both are closely related to *E. montanensis*, which Nelson refers to *Wyomingia*.

ERIGERON YELLOWSTONENSIS A. Nels. Bot. Gaz. **31**: 198. 1900
Erigeron lapiluteus A. Nels.; Coult. & Nels. New Man. Cent. Rocky Mts. 530. 1909.

Professor Nelson states in the New Manual that *Erigeron yellowstonensis* is a name to be rejected, but he does not state on what ground, probably because it is of barbaric origin, regarded from a Latin standpoint. But what should be said about *E. lapiluteus* which is to replace it? Is it Latin? It is probably meant to be derived from *lapis*, stone, and *luteus*, yellow. In making a compound word the Romans usually took the stem of the first word and connected it with the second word by means of the connecting vowel *i*. The stem of *lapis* is *lapid*, as seen from the genitive *lapidis*. The proper form would then have been *lapidiluteus*. But what would that have meant? Usually the Romans placed the modifying word first (not always though), as is done in the English, and the name *Erigeron lapidiluteus* would mean the "stone-yellow fleabane." The intention was evidently to name it the "fleabane of the yellow stone." The only proper way to express this would be by the specific name *lapidis lutei* or, as it has become the custom in botany to capitalize proper names, and use a hyphen when the specific name consists of more than one word, *Lapidis-lutei* or *Lutei-lapidis*, as the order of the adjective is indifferent.

Professor Nelson states also that "the variety *droebachensis* [of *E. acris*] probably does not occur in our range." *Erigeron droebachensis* Muell., is as common in the Rockies as is *E. yellowstonensis*. The question is whether they should be kept apart specifically. The only difference I can find is that the latter is more hairy with shorter hairs, decidedly glandular-puberulent in the inflorescence, and the involucre is more decidedly hirsute. In the

herbarium of the New York Botanical Garden there are several Scandinavian specimens of *E. droebachensis* Mueller (*E. Muelleri* Lund.), one from the vicinity of Christiania; the town of Droebach is only a short distance south of Christiania. These specimens are perfectly matched by specimens from Quebec, Subarctic America, Yukon, Canadian Rockies, and Colorado. *Erigeron acris* L., which is included in the New Manual, is on the contrary not found in America. It differs from all the North American species of the group, except the very rare *E. alpinus*, in having villous rather than hirsute or puberulent involucres.

ERIGERON COMMIXTUS Greene, Pittonia **5**: 58. 1902

E. cinereus A. Gray, Mem. Am. Acad. **4**: 68. 1849. Not *E. cinereus* H. & A. 1836.

E. colo-mexicanus A. Nels.; Coult. & Nels. New Man. Cent. Rocky Mts. 529. 1909.

Another specific name proposed by Professor Nelson, *Erigeron colo-mexicanus*, to replace the untenable *E. cinereus* A. Gray, is in my opinion rather distasteful. Fortunately I do not need to use the name, as the same species has been described by Dr. Greene under the name *E. commixtus*.

ERIGERON UNIFLORUS L. Sp. Pl. 864. 1753

The typical form of this species is, so far as I know, not found on this continent. As Dr. Greene has pointed out, the European species is characterized by narrow erect or ascending rays. This character is found also in *Erigeron pulchellus unalaschkensis* DC. Prod. **5**: 287 (*E. uniflorus pulchellus* Fries), which is not uncommon in America from Greenland to Labrador, Montana, and Alaska. In the latter the involucre is more or less turbinate, tapering into the enlarged end of the stem, and black-hairy, while in the typical *E. uniflorus* the involucres are hemispheric, and more or less white-hairy, and the stem is not thickened. Whether the two are specifically distinct or not is hard to tell. In Greenland both forms are found. If the variety is to be regarded as a species, **Erigeron unalaschkensis** (DC.) is the only available name, as *E. pulchellus* has been used by Michaux for another species.

The plant referred to *Erigeron uniflorus* in the Flora of Colorado

is distinct and easily distinguished by its broad spreading rays. The name it should bear is *E. simplex* Greene. *E. leucotrichus* Rydb. is a more luxuriant form of the same. It is questionable if *E. melanocephalus* Nelson should not be included in it also, differing only in the blackish hairiness of the involucre.

Professor Piper in his flora of Washington has transferred the name *Erigeron filifolius* (Hook.) Nutt. to what was usually known under the name *E. peucephyllus* A. Gray. This change was wholly unwarranted, I think. There are duplicates of the types of both *Diplopappus filifolius* Hook. and *Erigeron filifolius* Nutt. in the Columbia University herbarium, and they both belong to the species described under the latter name in Gray's Synoptical Flora. What probably led Professor Piper astray was the following words in Hooker's description: "*radiis flavescentibus*." This does not necessarily mean that the plant has yellow rays. The original meaning of *flavescens* is turning (light) yellow. White flowers often turn yellowish in drying. As *E. filifolius* has white as well as violet rays, the rays are often yellowish in drying.

WYOMINGIA

As instituted in the New Manual this genus is very unsatisfactory, for if the more imbricated bracts with thickened backs are made the distinguishing character separating *Wyomingia* from *Erigeron*, then *E. Garrettii* A. Nels., *E. tener* A. Gray, *E. Tweedyi* Canby, *E. caespitosus* Nutt., *E. nevadensis* A. Gray, *E. luteus* A. Nels., *E. filifolius* Nutt., etc., should be included in *Wyomingia*. If the achenes should count for anything, *E. montanensis* and perhaps *E. canus* could not very well be included. The former has flattened achenes and the latter has glabrous and 8–10-nerved achenes, while the rest of the genus has pubescent and 4–5-angled achenes. It would be desirable to take out *Wyomingia* as a genus, for the plants fit rather poorly in *Erigeron*, but the question is where to draw the line. The species with flattened achenes with the involucre of *Wyomingia* would constitute a rather natural genus, but such species as *E. utahensis* destroy the distinctness.

ANTENNARIA

A footnote under this genus in the New Manual states: "The treatment of this genus is largely an adaptation of Professor Elias

Nelson's clear and discriminating revision of a large part of the genus." While Elias Nelson's treatment is in the main excellent, the writer is inclined to take some exceptions to this as well as to that of the New Manual. In the latter we find the following key of the *A. alpina* group:

Stems very slender, 2–7 cm. high.	1. *A. media.*
Stems medium, 8–15 cm. high.	
Leaves broadly spatulate; involucres 6–7 mm. high.	2. *A. fusca.*
Leaves spatulate-oblanceolate; involucres about 5 mm. high.	
Leaves obtuse, tomentose.	3. *A. reflexa.*
Leaves acute, canescent.	4. *A. umbrinella.*

The only species that can be separated out by this key is *Antennaria fusca*. The key is not workable otherwise. *A. media* is often 8–10 cm. high and *A. umbrinella* and *A. reflexa* are often less than 7 cm. high. In both *A. reflexa* and *A. umbrinella* as limited in the New Manual and in E. Nelson's paper are the leaves both tomentose and canescent, as the one word indicates the kind of pubescence, and the other word the color of the same. E. Nelson merges *A. mucronata* E. Nels. in *A. umbrinella* Rydb. and *A. flavescens* Rydb. in *A. reflexa* E. Nels. Under the latter he makes the following statement: "In describing *A. umbrinella* Dr. Rydberg confused two species . . . The male and female plants of his type are of different species. One of these he later named *A. flavescens*, and the staminate plants of this and his *A. umbrinella* are identical." It is true that there were a few staminate specimens of *Antennaria flavescens* mixed in the type collection of *A. umbrinella*, but there were also a few staminate specimens of the latter. I saw the plant in field, as I was present when Professor J. Flodman collected the type, but we did not then notice that another species was growing with it. The staminate plants of *A. umbrinella*, *A. flavescens*, and *A. reflexa* are very much alike and hard to separate. *A. flavescens* has somewhat narrower bracts and the leaves are usually more or less yellowish and with a very fine and closely appressed silky tomentum. The difference between the staminate plants of *A. umbrinella* and *A. reflexa* I can not describe. The staminate plant of *A. mucronata* is very different, more resembling that of *A. media*, but the inner bracts are nearly white, the outer very dark brown. E. Nelson states that typical staminate plants are unknown. The only ones I

have seen and which I think belong here are *Goodding 430*, from Ten Sleep Lakes, Big Horn County, Wyoming, and labeled *A. nardina*.

The pistillate plants of the four species are easier to distinguish. *Antennaria mucronata* has very dark greenish brown bracts, as dark as those of *A. media* but the inner bracts are oval, obtuse or even rounded at the apex, and inclined to be white-tipped. The leaves of the rosettes are narrower and with more appressed pubescence. The bracts of the pistillate head of *A. umbrinella* have about the same shape as those of *A. mucronata* but are from light umber-brown to almost yellowish, and of the same color throughout. The leaves are much shorter and broader, like those of *A. media*, but with appressed tomentum. The bracts of the pistillate heads of *A. flavescens* are still lighter than those of *A. umbrinella*, being yellowish or brownish white, oblong and scarcely more than half as broad, but still obtuse. The leaves are yellowish. It would have been better to have designated *Rydberg & Bessey 5146* instead of *5145* as the type, because the former number contains pistillate as well as staminate plants. The pistillate heads of *A. reflexa* have bracts of a color similar to that of *A. umbrinella* but they are decidedly acute and resemble those of *A. media* in shape.

The staminate plants of this group are very rare, except in *Antennaria flavescens*, in which it is the common form, the pistillate plant being comparatively rare. In the herbarium of the New York Botanical Garden the staminate plants are represented by the following specimens:

Antennaria alpina (L.) Gaertner: *J. Källström* (Tronfjeld, Norway).

A. monocephala DC.: *Wm. Horne* (Karluk, Alaska), *Blaisdell* (Cape Nome, Alaska).

A. media Greene: *Hall & Chandler 686* (Mt. Goddard, Calif.); *Sonne 160* in 1888 (Bear Creek, Placer Co., Calif.) and in 1892 (Coldstream, Calif.).

A. mucronata, E. Nels.: *L. Goodding 430* (Ten Sleep Lakes, Wyo.).

A. umbrinella Rydb.: *Flodman 859* (partly) (Long Baldy, Mont.); *Macoun 69339* (Meyer's Creek, B. C.); *Umbach 615* (Midvale, Mont.); *Rydberg & Bessey 5164* (Mt. Chauvet, Idaho); *Shear & Bessey 3971* (Steamboat Springs, Colo.).

A. flavescens Rydb.: many specimens.

A. reflexa E. Nels.: *Goodding 114* (Pedro Mountains, Wyo.); *Goodding 380* (Doyle Creek, Wyo.); *A. Nelson 853* (Union Pass, Wyo.).

A. pulvinata Greene: *Richardson* (?), from Hooker's herbarium.

Antennaria rosea (D. C. Eat.) Greene has a peculiar history. The citation of Eaton should perhaps be omitted, for Eaton* gave no description. The first description was given by myself under the name *A. parvifolia*,† on the supposition that it was the same as *A. parvifolia* Nutt.‡ It might have been included partly in the description of that species, but Professor Piper has shown that Nuttall's type belongs rather to *A. aprica* Greene. It was afterwards described by Greene as *A. rosea*,§ the author giving *A. dioica rosea* Eaton as a synonym. As that was a *nomen nudum*, it should be "ignored" as Greene‖ stated later, and *A. rosea* is based wholly upon Greene's description. The type of *A. rosea* would then be *Sheldon 128*, which is first cited, rather than *Watson 652*, which is not cited at all. *Sheldon 128* is the monotype of Greene's *A. sordida*.¶ The proposer of the latter must have forgotten or ignored what he had done a year earlier. E. Nelson gives *A. sordida* as a synonym of his *A. rosea angustifolia*, based on my *A. angustifolia*.** There is no use of keeping up a variety if the type of the species belongs to the variety! Besides, *Sheldon 128* and *Watson 652* are almost identical. *A. angustifolia* Rydberg is somewhat similar, but has narrower involucral bracts, of which the inner are very acute. It is not found in the Rocky Mountain region.

In the New Manual, *A. anaphaloides* Rydb. is made a synonym of *A. pulcherrima*. Piper, who is fully as "conservative" as A. Nelson, keeps them distinct, however. So did also E. Nelson. The description of *Antennaria pulcherrima* in the New Manual is an almost verbatim copy of my description of *A. anaphaloides*. The description, especially that of the pistillate head, does not

*Bot. King Exp. 186. 1871.
†Bull Torrey Club **24**: 301. 1897.
‡Trans. Am. Phil. Soc. II. **7**: 406.
§Pittonia **3**: 281. 1898.
‖Pittonia **4**: 81. 1899.
¶Pittonia **4**: 81. 1899.
Bull. Torrey Club **26: 546. 1899.

at all agree with a duplicate of the type of *A. pulcherrima* in the Torrey herbarium. In the latter, the bracts are imbricated in 6 or 7 series, wholly brown, the innermost very narrow and acuminate. *A. foliacea* Greene is wholly ignored, although E. Nelson had it in his paper. *A. Sierrae-Blancae* Rydb. is made a synonym of *A. rosulata*, although the words "leaves glabrate above" are added after the reference. Probably the authors had not seen any specimens. The characters of the bracts (not referred to) are a better distinction than the mere lack of tomentum. On the other hand, *Antennaria oblanceolata* Rydb. is kept distinct from the closely related *A. luzuloides*. In the key the latter is placed under the heading "bracts tomentose except the scarious tips"; but in the description is stated "involucres glabrous nearly or quite to the base." The latter characterization is correct and *A. luzuloides* should be associated with *A. oblanceolata* instead of *A. pulcherrima* in the key.

Antennaria acuta sp. nov.

A surculose-stoloniferous perennial; stems slender, 5–12 cm. high; stolons short and mostly ascending; basal leaves and those of the stolons narrowly oblanceolate, greenish-white, tomentose on both sides, glabrate in age, 15–25 mm. long, 2–4 mm. wide, acute or abruptly short-acuminate; tomentum very fine and appressed; stem-leaves narrowly linear or linear-oblanceolate; heads 3–5, conglomerate, sessile; involucres about 6 mm. high, tomentose below; bracts of the pistillate heads lanceolate to linear-lanceolate, dark greenish brown with slightly lighter tips, the inner acute.

This is related to *Antennaria alpina* and *A. media*. It resembles perhaps most the former but the leaves are equally tomentose on both sides. From *A. media* it differs in the narrower, acute or acuminate leaves with a finer, closely appressed tomentum.

ALBERTA: Marsh near Lake O'Hara, Aug. 8, 1904, *J. Macoun 65423* (type in herb. N. Y. Bot. Gard., duplicate in herb. Geol. Surv. Canada); also Bow River at Laggan, July 25, 1904, *65413;* and Pipestone Creek, July 6, 1904, *65422*.

GNAPHALIUM

In Coulter & Nelson's New Manual both *Gnaphalium sulphurescens* Rydb. and *G. thermale* E. Nels. are cited as synonyms of

G. Wrightii. *G. thermale* is closely related to that species and may be regarded as a form thereof by a conservative systematist, but the first one named is not.

At the end of the description of *Gnaphalium Wrightii* the following note is given: "*G. thermale* E. Nels. Bot. Gaz. **30**: 121. 1900, the description of which is here used." If *G. thermale* is to be included in *G. Wrightii*, it is at least not the normal condition of that species and the description of the small *G. thermale* gives a poor idea of *G. Wrightii*, which is a tall plant, 3–5 dm. high. To use the description of one species for another is as a rule very unsafe, unless the identity is established without any doubt.

Gnaphalium albescens Osterh., *G. proximus* Greene, and *G. lagopodioides* Rydb. are not accounted for at all in the New Manual, although they were described from material collected in the region covered by the work. The first, I think, is a pure synonym of *G. Wrightii;* the other two, as well as *G. sulphurescens*, are closely related to *G. chilense* Sprengel (*G. Sprengelii* H. & A.). All three have the obtuse bracts and subdecurrent leaves of that species. *G. proximus* was based on *Aven & Elias Nelson 6036* and is closest to *G. chilense*. The specimens were distributed as *G. Sprengelii* and are evidently included in *G. chilense* in the New Manual. If *G. sulphurescens* should be reduced to synonymy it should be under *G. chilense* not under *G. Wrightii*.

Gnaphalium uliginosum L. is also omitted, although it has been collected in both Colorado and Utah.

Gnaphalium angustifolium A. Nels. is antedated by both *G. angustifolium* Lam. and *G. angustifolium* Loisel.; but as those species now are referred to *Helichrysum* it may be that *G. angustifolium* is tenable according to the Vienna Rules. A poor rule indeed, when the validity of the name *G. angustifolium* A. Nels. depends upon whether two species of the Old World are kept in *Gnaphalium* or not. Three years after *G. angustifolium* A. Nels. was published, the proposer of that species substituted the name *G. exilifolium*, which name is wholly ignored in the New Manual.

Gnaphalium Williamsii sp. nov.

Probably biennial; stem 3–6 dm. high, branched above, loosely floccose; leaves linear or linear-lanceolate, decurrent, 5–10 cm. long,

almost equally floccose on both sides with loose, not dense tomentum, sometimes slightly glandular; inflorescence large, corymbosely paniculate; heads somewhat conglomerate at the ends of the branchlets; involucre hemispheric or nearly so, 6 mm. high, only slightly tomentose at the base; bracts broadly ovate, acute, light straw-colored or white; achenes glabrous; pappus straw-colored.

This species is intermediate between *Gnaphalium microcephalum* and *G. decurrens*; perhaps more closely related to the latter, of which it has the general habit and the larger nearly hemispherical involucres, but the leaves are nearly as tomentose above as beneath. They are slightly if at all glandular; the stem is not at all so. The pubescence is that of *G. microcephalum* but the inflorescence is more open and inclined to be flat-topped and both the involucre and its bracts are much broader.

MONTANA: Columbia Falls, Aug. 11, 1894, *R. S. Williams* (type, in herb. N. Y. Bot. Gard.); woods, Belton, Aug. 25, 1903, *Umbach* 752.

NACREA A. Nels.

I believe that this genus is based on the essentially staminate plant of *Anaphalis*. There is a duplicate of the type of *Nacrea lanata* in the herbarium of the New York Botanical Garden, but the specimens are so young that the real structure of the flowers can not be made out. It may be that Nelson had better developed material on hand. The expressions "akenes (immature in these specimens)" indicate, however, that he did not have developed fruit. The so-called staminate flowers of *Anaphalis* are in reality hermaphrodite flowers with sterile pistils. (See Bentham & Hooker, Genera Plantarum.) The styles in them are undivided and the achenes remain undeveloped. In the description of *Nacrea* there is nothing said about the styles being undivided or 2-cleft. In the herbarium of the New York Botanical Garden there are two specimens collected in the Big Horn Mountains, one by T. A. Williams in 1898, and the other by Dr. H. Hapeman in 1892, which (especially the first mentioned) are so close in every respect to the duplicate of the type of *Nacrea lanata*, that anybody would take them for the same species. They are better developed and belong without doubt to an *Anaphalis*. Whether they can be separated specifically from *A. subalpina* is doubtful.

Anaphalis angustifolia sp. nov.

Perennial with a creeping rootstock; stems slender, strict, simple, white-tomentose, 3–6 dm. high; leaves narrowly linear, 1-nerved, 5–10 cm. long, 2–5 mm. wide, ascending, densely white-tomentose beneath, less so above, greener and often glabrate in age; inflorescence small, corymbiform, 2–3 cm. high, 3–4 cm. wide; heads hemispheric; involucres about 5 mm. high; bracts pearly white, elliptic, obtuse or acutish.

This species is more related to the eastern *Anaphalis margaritacea* than to *A. subalpina*, having narrow and 1-ribbed leaves, but differs in the smaller inflorescence, smaller heads, narrower bracts, and narrower and ascending instead of spreading leaves.

MONTANA: Mount MacDonald, July, 1900, *Elrod & assistants* (type, in herb. N. Y. Bot. Gard.); Big Fork, Aug. 9, 1901, *Umbach 15*.

BALSAMORRHIZA

Professor Nelson has reduced *Balsamorrhiza hirsuta* Nutt. and *B. terebinthacea* Nutt. to varieties of *B. Hookeri* and *B. macrophylla* respectively. Although the first has a superficial resemblance in the cutting of the leaves to *B. Hookeri*, it is much more closely related to *B. macrophylla* in every respect, differing only in the smaller heads and more dissected leaves. In his key Professor Nelson gives the following characters:

Leaves entire or somewhat toothed.	1. *B. sagittata.*
Leaves not entire, laciniately dentate to bipinnatifid.	
Green, glabrous or sparingly hisute.	2. *B. macrophylla.*
Canescent or lanate.	
The sericeous pubescence appressed or spreading.	3. *B. Hookeri.*
The white tomentum often floccose.	4. *B. incana.*

How would it be possible to locate *B. Hookeri hirsuta* by means of this key? As its leaves are pinnatifid, green, and hirsute, it would key into *B. macrophylla* instead of *B. Hookeri*. On the following page Professor Nelson gives only the following: "The pubescence roughish hirsute and spreading, not canescent or tomentose," as distinguishing the var. *hirsuta* from *B. Hookeri*, just the same characters which he in the key has used as separating *B. macrophylla* from *B. Hookeri*. The latter is not found within the range.

Balsamorrhiza terebinthacea Nutt. is not closely related to *G.*

macrophylla. In the latter the outer involucral bracts are elongated and reflexed; the former has the involucre of *B. Careyana* with appressed bracts. I doubt that *B. terebinthacea* is found east of northwestern Idaho.

It is a kind of puzzle to me, to determine what rule Professor Nelson followed in making these reductions. The specific name *terebinthacea* (1833) is much older than *macrophylla* (1841), and even where Nuttall transferred the former from *Heliopsis* to *Balsamorrhiza* it has page priority. If united, *B. terebinthacea* should be the species and *B. macrophylla* the variety.

Balsamorrhiza floccosa Rydb. and *B. tomentosa* Rydb. were reduced to synonyms of *B. incana* and *B. sagittata* respectively. It may be admitted that they (especially *B. tomentosa*) are closely related to the species to which they are referred, but I doubt if the authors of the New Manual have seen authentic material of either. In the Bulletin of the Torrey Botanical Club, November, 1900, I gave a synopsis of the Rocky Mountain species of this genus, and have not found any material change to make since that time.

Gymnolomia linearis sp. nov.

Perennial with a rootstock or slender caudex; stems 3–4 dm. high, terete, strigose; leaves opposite, short-petioled, narrowly linear, 3–4 cm. long, 2–4 mm. wide, entire, hirsutulous, indistinctly 3-nerved, sparingly hispid-ciliate at the base; heads long-pedunculed; involucres about 6 mm. high, 12–15 mm. broad; bracts linear-lanceolate, canescent-strigose; rays 10–12 mm. long, 3–4 mm. wide.

This species resembles *Gymnolomia longifolia* and *G. annua* in leaf form and general habit, but it is a perennial. From *G. multiflora* it differs in the narrow leaves and the slender perennial base, which would be classified rather as a rootstock than a caudex. The type number was included in *G. multiflora* by Robinson and Greenman* as a narrow-leaved form. The other specimens cited by them as belonging to this form, I have not seen, but probably they should be included in *G. linearis*.

UTAH: St. George, 1877, *E. Palmer* 241 (type, in herb. Columbia Univ.).

*Proc. Boston Soc. Nat. Hist. **29**: 92. 1899.

Gymnolomia ciliata (Robins. & Greenm.) Rydb. sp. nov.

Gymnolomia hispida, var. *ciliata* Robins. & Greenm. Proc. Boston Soc. Nat. Hist. **29**: 93. 1899.

HELIANTHUS

The authors of the New Manual have reduced *Helianthus aridus* Rydb. to a synonym of *H. petiolaris*. Although the forms of its leaves resemble those of that species, *H. aridus* is much more closely related to *H. lenticularis* (*H. annuus* of the Manual), which is indicated by the form of the bracts and the pubescence. If it should be reduced at all, it should be made a variety of *H. lenticularis*. It may even be a depauperate form of that species.

Helianthus giganteus is omitted, although unquestionable specimens have been collected in Colorado. (See my Flora of Colorado, page 372.)

HELIANTHELLA

In the New Manual *Helianthella uniflora* is described in the key as having a purple disk. In all specimens I have seen the disk-corollas are yellow. *H. Douglasii* is not included in the flora, although it has been collected in Montana by F. W. Anderson and Tweedy, in the Yellowstone Park by Tweedy, and south thereof in Wyoming by C. C. Curtis. (See also my Flora of Montana and the Yellowstone National Park.)

ENCELIOPSIS

Enceliopsis nutans (Eastwood) A. Nels., from Colorado and Eastern Utah, is omitted in the New Manual. This is strange, as Professor A. Nelson is the author of the name *Enceliopsis* as well as of the combination *E. nutans*.

BIDENS

Bidens bipinnata L. is included in Coulter & Nelson's New Manual. I have not seen any specimens from the Rocky Mountain region that could be referred to that species. *B. Bigelovii* is, however, found in Colorado. *Crandall 2726*, *Shear 4587*, *Clements 64* and *82*, all resemble so closely the Mexican Boundary Survey *no. 582* and *no. 582a*, from which *B. Bigelovii* was described, that there is no doubt about the identity. Duplicates of

these two numbers of the Boundary Survey are in both the herbarium of the Columbia University and that of the New York Botanical Garden. The structure of the marginal achenes distinguishes *B. Bigelovii* at once from *B. bipinnata*.

THELESPERMA

In the description of *Thelesperma ambiguum* in Coulter & Nelson's New Manual, we find the following: "bracts of the outer involucre 8, subulate-linear, almost equalling or half the length of the inner," etc. In Wright's specimens, from which *T. ambiguum* was described, the outer bracts are ovate or elliptic, scarcely one fourth as long as the inner involucre. What is described in the New Manual is evidently *T. intermedium* Rydb. When I described the latter, I had known it for about ten years and had never been able to make it agree with Dr. Gray's description of *T. ambiguum* in the Synoptical Flora. In the original publication of *Thelesperma ambiguum* no diagnosis is given, only a few characters distinguishing it from related species. In habit *T. ambiguum* resembles most *T. subnudum*, having the creeping rootstock of that species, the long naked peduncles, and the leaves found near the base of the stem only. The range is given as Montana to New Mexico and Texas. This was probably taken from the Synoptical Flora. The specimens on which Dr. Gray extended the range to Montana belong to *T. marginatum*, in many respects closely related to *T. ambiguum* but with discoid heads. *T. ambiguum*, as far as I know, is not found north of southern Colorado. *T. intermedium*, which is really described under the name of *T. ambiguum* in the New Manual, does not have a "creeping rootstock" (as Gray described *T. ambiguum*) but has a biennial or perennial taproot; and it has a leafy stem. As the authors of the New Manual did not at all consider the differences in the subterranean parts of *T. ambiguum* and *T. intermedium*, it was natural that they would not consider the same parts in *T. trifidum* and *T. tenue*, which resemble each other much more closely, and we find the latter as a synonym of the former. *Thelesperma marginatum* Rydb. is ignored altogether, although in my Flora of Montana four collections from that state are cited.

HYMENOPAPPUS

Professor Nelson divides this genus into two groups: one with stems leafy throughout, mostly corymbosely branched and with numerous heads; the other with stems leafy below, the leaves reduced upwards, few or wanting, heads not numerous. In the first group, he places *Hymenopappus tenuifolius* and *H. luteus*. The first of these two always has a leafy stem and many heads, but in *H. luteus* the stem is not more leafy than it often is in *H. filifolius* and *H. cinereus*, and as a rule has less numerous heads than either of them. In the key of the New Manual *H. scaposus* is distinguished from the rest by the following character: "stem scapose, less than 2 dm. high." These characters we often find in both *H. luteus* and *H. araneosus*.

Hymenopappus cinereus Rydb. and *H. ochroleucus* Greene are made synonyms of *H. araneosus*. I take the two first to be the same, but think that the last one should be kept distinct. It is characterized by the denser, more permanent tomentum, a tuft of dense matted white tomentum on the caudex, and achenes with silky and more appressed pubescence. This is characteristic of neither *H. cinereus* nor *H. ochroleucus*. *Hymenopappus parvulus* Greene is made a synonym of *H. scaposus*, but it has a smaller head, no matted white tomentum on the caudex and subcylindraceous corolla-throat. The last character would associate it with *H. macroglottis*, *H. lugens*, and *H. eriopodus*, but its corollas are scarcely more than half the size of those of the other species. *H. scaposus* is not found in the region, as limited in the New Manual.

Hymenopappus lugens Greene is to be added to the region, having been collected above Marysvale, Utah, July 21, 1905, *Rydberg & Carlton 7049*, and *H. eriopodus* A. Nels., found in Diamond Valley, May 19, 1902, *Goodding 880*, and at Springdale, May 14, 1894, *Jones 5261*. The last has much broader segments to the leaves than the type and resembles *H. tomentosus* in habit, but has the corolla of *H. eriopodus*. It may prove to be distinct.

OTHAKE

In describing *Polypteris maxima*, Dr. J. K. Small overlooked the fact that the original *Palafoxia Hookeriana* was based on Drummond's plant, which he referred to *Polypteris maxima*. Mr. Bush,

in reëstablishing Rafinesque's genus *Othake* did not notice this discrepancy and the name *Othake Hookerianum* has hitherto been applied to the wrong species. The synonymy of the two species is as follows:

OTHAKE HOOKERIANUM (T. & G.) Bush, Trans. Acad. Sci. St. Louis **14**: 177. 1904

Palafoxia texana Hook. Ic. Pl. *pl.* 148. 1837. Not *P. texana* DC. 1836.

Palafoxia Hookeriana T. & G. Fl. N. Am. **2**: 368. 1842.

Polypteris maxima Small, Fl. SW. U. S. 1288. 1903.

Othake maximum Bush, Trans. Acad. Sci. St. Louis **14**: 179. 1904.

Both Hooker's description of *Palafoxia* and Torrey and Gray's description of *P. Hookeriana* were based on Drummond's specimens, of which there is a duplicate in the Columbia herbarium, and this belongs to *Polypteris maxima* Small. Hooker's plate also illustrates the same thing. It was not strange that Dr. Small was led astray, for the true *O. Hookerianum* is a very rare plant and it was natural to think that the common plant which had been taken for it by Gray, Porter, Coulter, Greene, A. Nelson, myself, and others, should be regarded as *O. Hookerianum*. The latter species should be known as

Othake sphacelatum (Nutt.) Rydb. nom. nov.

Stevia sphacelata Nutt.; Torr. Ann. Lyc. N. Y. **2**: 214. 1827.

Palafoxia Hookeriana subradiata T. & G. Fl. **2**: 368. 1842.

Polypteris Hookeriana A. Gray, Proc. Am. Acad. **19**: 30, mainly.

Othake Hookerianum Bush, Trans. Acad. Sci. St. Louis **14**: 177, as to the description. 1904.

Bush gives as a doubtful synonym *Othake longifolium* Raf.,* but the description does not fit this plant. *O. longifolium* is compared with *O. tenuifolium* Raf., *i. e.*, *Othake callosum* (Nutt.) Bush, and said to be much smaller in every respect than that species. *O. sphacelatum* has about twice as large heads as *O. callosum*.

Torrey's description of Nuttall's *Stevia sphacelata* is rather poor and not ample enough to recognize any species by, but the type, collected by James, is in the old Torrey herbarium and it is un-

*New Fl. Am. **4**: 74. 1838.

mistakably the plant here considered. Being the only available and certain specific name of the plant, *sphacelatum* is therefore taken up.

Othake macrolepis sp. nov.

Annual; stem 3–4 dm. high, strigose-puberulent, and glandular on the upper parts, with ascending branches; leaves alternate, linear, indistinctly 1-ribbed, strigose-puberulent on both sides, 3–5 cm. long, 2–3 mm. wide, short-petioled; involucres obconic, 9–10 mm. high and about as wide; bracts 8–12, in two subequal series, linear-oblanceolate, abruptly acute, scabrous-hispidulous and slightly glandular, green, with scarious tips, and the inner with narrow scarious margins; rays none; disk-corollas rose-purple, 14–15 mm. long; limb 4–5 mm. long, with linear lobes; achenes linear-obpyramidal, 7 mm. long, 1 mm. thick at the apex, strigose-canescent, pappus-scales 6–8, lanceolate, caudate-acuminate 5–6 mm. long.

This species is most closely related to *O. roseum* Bush, but has much larger heads, flowers, and fruit, and the leaves have a less distinct midrib. In the type of *O. roseum* the disk-corollas are only about 12 mm. long. There is no full-grown fruit in the type sheet, but other specimens show that the achenes are only 4–5 mm. long and their pappus-scales 2–3 mm. long, acute rather than caudate.

COLORADO: Rule Creek, Bent Co., Aug. 17, 1909, *G. E. Osterhout 4097* (type, in herb. N. Y. Bot. Gard.).

PICRADENIOPSIS

In the New Manual, my genus *Platyschkuhria* is accepted, but *Picradeniopsis* Rydb., fully as distinct from *Bahia*, is retained in the latter genus. In *Picradeniopsis* and *Achyropappus* the foliage is impressed-punctate, and the leaves opposite, which is not the case in the other genera included by Gray in *Bahia*. *Bahia* is a shrubby plant of South America with white rays. Using Professor Nelson's generic key, *Picradeniopsis* would key into *Hymenoxys*. It stands nearest to that genus, which has been known under the name *Picradenia*, but differs in the free bracts. *Picradeniopsis* is amply distinct from the non-punctate and alternate-leaved *Bahia* but may have been included in *Achyropappus*. The annual habit and rayless heads of that genus seem to be distinction enough.

Picradeniopsis Woodhousii (A. Gray) Rydb. comb. nov.

Achyropappus Woodhousii A. Gray. Proc. Am. Acad. **6**: 546. 1865.
Schkuhria Woodhousii A. Gray, Proc. Am. Acad. **9**: 199. 1874.
Bahia Woodhousii A. Gray, Syn. Fl. 1^2: 333. 1884.

Dr. Gray in the work last cited includes this species in the annual species of *Bahia*. The plant is, however, perennial with a creeping rootstock, and in habit so closely resembling *P. oppositifolia* that it is often hard to distinguish the two. The flowers are of a much lighter color in *P. Woodhousii*, the rays being ochroleucous or straw-colored, and the pappus-scales are much narrower, lance-subulate, and only slightly scarious-margined.

This should have been included in the New Manual, as the type was collected in northern New Mexico.

PLATYSCHKUHRIA

Platyschkuhria oblongifolia (A. Gray) Rydb. should have been included in Coulter & Nelson's New Manual. It has been collected in southwestern Colorado. See Gray's Synoptical Flora 1^2: 332, and my Flora of Colorado 377.

Platyschkuhria desertorum (Jones) Rydb. comb. nov.

Bahia desertorum M. E. Jones, Zoe **2**: 249. 1891.

This species is a close ally to *P. integrifolia*, differing mainly in the acuminate bracts.

VILLANOVA

By an oversight *Bahia dissecta* (A. Gray) Britton (*B. chrysanthemoides* A. Gray) was retained in *Bahia* in my Flora of Colorado. It should have been restored to *Villanova*. As nobody seems to have used this generic name in connection with the earliest specific one, the plant should be known as:

Villanova dissecta (A. Gray) Rydb. comb. nov.

Amauria ? dissecta A. Gray, Mem. Am. Acad. **4**: 104. 1849.
Villanova chrysanthemoides A. Gray, Pl. Wright **2**: 96. 1853.
Bahia chrysanthemoides A. Gray, Proc. Am. Acad. **19**: 28. 1883.
Bahia dissecta Britton, Trans. N. Y. Acad. Sci. **8**: 68. 1889.

CHAENACTIS

Chaenactis achilleaefolia H. & A. and *C. pedicularia* Greene are both reduced in the New Manual, the former to a variety of *C. Douglasii*, the latter to a synonym of *C. alpina*. I think that both should be kept up as species. The characters separating the former from *C. Douglasii* are not so much the dwarf habit and reduced crowded segments of the leaves, for such conditions are found in the true *C. Douglasii*, as the permanent tomentum and the longer and acute pappus-scales. *C. alpina* is subscapose with peduncles 2–7 cm. long and its involucre is much shorter than the corollas. *C. pedicularia* has leafy although short stems, very short peduncles 1–2 cm. long, and involucral bracts, in the specimens seen, fully as long as the flowers. Apparently *C. pedicularia* is the same as *C. Douglasii*, var. *montana* M. E. Jones,* of which the author states that it has been confused with *C. alpina*, but at the same time points out several distinctions.

CHAMAECHAENACTIS

In reviewing Coulter & Nelson's New Manual, Dr. B. L. Robinson† stated: "No mention, for instance, is made of *Encelia nutans* Eastwood and *Chaenactis scaposa* Eastwood." This is not exactly true, for the latter is included in the New Manual. It was not strange, however, that Dr. Robinson should overlook the fact, for who would expect to find it under the name *Actinella carnosa* A. Nels.? I doubt if Professor Nelson has seen any specimens, for if he had I do not think he would have transferred it to *Actinella*. The description in the New Manual is a verbatim copy of Miss Eastwood's description. The plant is evidently more closely related to *Chaenactis*, in which genus it was first placed, than to *Actinella*. If Professor Nelson was unwilling to adopt my generic name *Chamaechaenactis*, it would have been much better to retain the species in *Chaenactis* than to transfer it to *Actinella*, where it is wholly out of place. Besides, *Chamaechaenactis* is fully as good as Nelson's own genera *Tonestus* and *Wyomingia*, and far more so than *Nacrea* and *Enomegra*. The last has no scientific standing at all, being distinguished from *Argemone* only by the

* Proc. California Acad. Sci. II. **5**: 700. 1895.

†Rhodora **12**: 16. 1910.

yellow instead of milky white sap. In which genus should a species with ochroleucous or white sap, turning yellowish, be placed?

Correction

The California specimens referred to *Scutellaria veronicifolia* in a previous installment of the studies belong to *S. californica* A. Gray, and not to the former, having a different corolla.

NEW YORK BOTANICAL GARDEN.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1909)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Ames, O. Notes on Philippine orchids with descriptions of new species, I. Philippine Jour. Sci. **4**: (Bot.) 593–600. N 1909.

Anderson, J. P. Notes on the flora of the Great Plains—I. Iowa Nat. **2**: 40, 41. Jl 1909.

Bartlett, H. H. The submarine *Chamaecyparis* bog at Woods Hole, Massachusetts. Rhodora **11**: 221–236. *pl. 82 + map.* 29 D 1909.

Bay, J. C. Bibliographies of botany. A contribution toward a bibliotheca bibliographica. Prog. Rei Bot. **3**: 331–456. 1909.

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Boldingh, E. The flora of the Dutch West Indian Islands St. Eustatius, Saba, and St. Martin. i–xiii. + 1–321. *Map.* Leiden, 1909.

Börgesen, F. Notes on the shore vegetation of the Danish West Indian Islands. A supplement to my earlier paper on the halophyte vegetation of the islands. Bot. Tidsskr. **29**: 201–251. *pl. 3, 4 + f. 1–40.* 13 Ap 1909.

Børgesen, F. Some new or little known West Indian *Florideae*. Bot. Tidsskr. **30**: 1–19. *pl. 1, 2 + f. 1–11*. 23 O 1909.

Includes new species in *Chantransia* (2), *Nemalion* (2), *Callithamnion*, and *Seirospora*.

Bouly de Lesdain, M. Notes lichénologiques. No. X. Bull. Soc. Bot. France **56**: 473–477. 2 D 1909.

Includes 8 new American species in *Gyalolechia*, *Aspicilia*, *Psora*, *Bacidia*, *Toninia*, *Heppia*, *Polyblastia*, and *Pharcidia*.

Britton, N. L., & Rose, J. N. The genus *Cereus* and its allies in North America. Contr. U. S. Nat. Herb. **12**: 413–437. *pl. 61–76*. 21 Jl 1909.

Bush, B. F. The Missouri saxifrages. Rep. Missouri Bot. Gard. **20**: 138–140. 1909.

Cannon, W. A. Studies in heredity as illustrated by the trichomes of species and hybrids of *Juglans*, *Oenothera*, *Papaver* and *Solanum*. i–iii + 1–67. *pl. 1–10 + f. 1–21*. Washington, D. C. 1909.

Carnegie Inst. Washington, Publ. no. 117.

Cannon, W. A. The root system of *Cereus giganteus*. In Spalding, V. M., Distribution and movements of desert plants, 59–66. *pl. 24 + f. 2*. Washington, D. C. 22 O 1909.

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Christ, H. *Polypodiaceae* II. [In Hassler, Ex herbario Hassleriano: Novitates paraguarienses. III.] Repert. Nov. Spec. **7**: 374, 375. 15 D 1909.

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